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Topics of the Month

The Cremer report and after

NEARLY six months have passed since the appearance of the Cremer Committee's report* which exposed the weakness in facilities for British chemical engineering research and made specific recommendations for remedying them. This report seemed at the time to herald a new national policy for chemical engineering in Britain, the cornerstone of which was to be the creation of a central research organisation which, in co-operation with industry, would collect data from large-scale operations, analyse it and issue it quickly to those responsible for plant design. Unfortunately, little has happened in the past six months to convince anyone that a serious effort is being made to create the organisation advocated by Cremer and his colleagues. So far as we can ascertain, all that has happened has been the decision of the Department of Scientific and Industrial Research to publish a series of critical bibliographies on particular aspects of chemical engineering technique and to invite the Institution of Chemical Engineers to help in this work. All this is admirable but it is negligible compared with what has been advocated and disappointing to those who thought that something drastic was to be done at last to correct British backwardness in chemical engineering.

Those who are dissatisfied with the lack of progress made in implementing the Cremer recommendations found an authoritative spokesman last month in Sir Harold Hartley, retiring president of the Institution of Chemical Engineers. In a wise and thoughful survey, ' Chemical Engineering at the Crossroads,' which we hope to publish in our next issue, he spoke of the urgent need for the organisation envisaged in the report. He went further in advocating, in addition to the central organisation, a pilot plant laboratory to carry out the experimental investigations to fill in the gaps in our knowledge which, he thought, would inevitably be exposed by the analysis of plant operations which would be the work of the central organisation. Without such a laboratory, he thought, our design and construction industry would be seriously handicapped.

Sir Harold underlined the urgency of grappling with the defects in chemical engineering research organisation by pointing out that until we recovered the initiative in chemical plant design and construction, we should be forced to continue to buy the know-how at a high cost from abroad ' and it will not be the latest know-how.' This initiative could only be regained by analytical and synthetic research for the co-ordination and application of which the organisation recommended by the Committee was essential. ' Without it we shall not benefit from the results of our own scientific research which in the past have so often been exploited abroad.'

All this is well worth saying and we hope that government departments, industry, trade associations, the universities and all who can influence the development of chemical engineering research will bear it fully in mind.

*See INTERNATIONAL CHEMICAL ENGINEERING, Jan. 1952, pp. 15, 23-27.

America wants British chemical engineers

IN Britain competition among companies and Government departments for the 1,000 or so chemical engineers expected to qualify between now and 1954 may be intensified by the entry of American firms into the market. This possibility is hazarded by *Chemical Engineering*, which reports that the shortage of chemical engineers in the U.S. is so critical that 'two of the biggest chemical companies are actually considering importing (*sic*) engineers from England. Today the cost of hiring a technical man is about $2,000. At that rate, these companies figure it may pay—it may even be necessary—to go to England for engineers.'

Comparing Britain's few thousand chemical engineers with America's 43,000, it seems to us fantastic that American firms should even consider attempting to recruit from our small chemical engineer force. Here, the problem of training more chemical engineers is lack of facilities. In America there are plenty of facilities, but too few entrants to the engineering colleges. Surely the most sensible way of tackling the problem is not for the Americans to try to recruit qualified British chemical engineers, but to offer training courses to would-be entrants to the profession and thus help to expand the total Anglo-U.S. force of chemical engineers. Not only British, but other European students also would probably welcome the chance of training for a chemical engineering career in America.

New oil desulphurising process

A NEW catalytic desulphurisation process, named 'Autofining,' has been developed by the Anglo-Iranian Oil Co. This process has been fully proved in extended operations in a 350-B.P.D. pilot plant and the first commercial size unit of 3,500-B.P.S.D. input capacity, in the Anglo-Iranian Llandarcy refinery in South Wales, was commissioned towards the end of 1951.

The process operates at pressures of 50-200 lb. gauge and at temperatures of 700-800°F. and makes use of a very stable sulphur-resistant catalyst which has a long life. The catalyst is regenerated periodically, the on-stream period varying with the boiling range of the feed stock. A small amount of gas, consisting mainly of hydrogen, is produced in the process and this is recycled. No hydrogen manufacturing facilities are required. It is claimed that a wide variety of feed stocks can be effectively desulphurised, ranging from natural and straight-run gasolines through naphthas and kerosines to gas oils and light diesel fuels. Sulphur removed from the feed stocks is largely converted into hydrogen sulphide. The products are said to be of good colour and odour and very stable. They need no subsequent refining treatment. The yields of liquid products obtained are 99% plus by weight or about 100% by volume.

Straight-run gasoline and naphtha feed stocks, having A.S.T.M. end points of up to about 400°F., can be almost completely desulphurised by this process and, at the same time, the octane number is raised by two or three numbers and the lead response considerably improved. With these feed stocks catalyst on-stream periods of 800 to 1,000 hr. between regenerations can be employed.

Kerosines are also almost completely desulphurised by the Autofining process and catalyst on-stream periods of about 400 hr. between regenerations are easily achieved. Of particular value for certain markets is the improvement in burning properties (*i.e.* char value) obtained.

Straight-run light gas oils (*i.e.* high-speed diesel fuels) may also be desulphurised. The degree of sulphur removal is lower than with lighter distillates, but in the case of Middle East crudes gas oils of 0.75 to 1% sulphur content can be desulphurised to the extent of 60 to 70% with catalyst on-stream periods of 200 hr.

In some refinery situations it may be more desirable to desulphurise a long distillate and fractionate after processing rather than desulphurise separate products after fractionation.

Other materials which may be satisfactorily desulphurised by the process include the highly aromatic extracts obtained by the solvent extraction of gasoline and kerosine fractions. The process is not normally applicable to residual fuel oils containing asphalt.

The expected consumptions of utilities in the 3,500-B.P.S.D. commercial unit at Llandarcy are:

150 lb. steam	6,600 lb./hr. (nett).
Cooling water	30,000 Imp. gal./hr.
Fuel	25,000,000 B.Th.U./hr.
Electric power	10 kw.

In this plant the recycle gas compressor is steam driven and steam is generated in a waste heat boiler.

It is estimated that the 3,500-B.P.S.D. commercial plant built in 1951 will have had a total erected cost within battery limits of approximately £250,000. Of this total cost, materials (including common building materials), draughting, engineering, procurement and contractors' overhead and profit, will have amounted to £196,000.

The process is covered by patents or patent applications in all major countries and is available for licensing by Anglo-Iranian Oil Co.

Soviet chemicals

THE Russian habit of giving production figures as percentages of previous outputs makes it extremely difficult to form any clear idea of the actual quantities of various materials which are being produced. However, if one has the basic figures upon which the percentage system of reporting production is based, it is possible to arrive at some comprehensible statistics. Presumably the American journal, *Chemical Week*, has used this method in estimating the production of certain basic chemicals in the Soviet Union. Beginning with sulphuric acid, it is estimated that production, based almost exclusively on the pyrites deposits in the Urals, is now more than 3,000,000 tons p.a. This seems a somewhat low figure and it would not be surprising if output is, in fact, greater. Most of this sulphuric acid is used to make phosphoric fertilisers, mainly the superphosphates, which, in turn, are based on the great apatite deposits on the Kola peninsula, near Finland. The works at Kirovsk is reported to be producing a 40% phosphorus pentoxide concentrate at the rate of 3,500,000 tons annually.

According to the American journal, the bottle-neck of Soviet chemical production is soda and other alkali metal salts. Annual requirements are placed at more than 1,600,000 tons, but as recently as 1950 output had climbed to only 900,000 tons, in spite of the rebuilding of the soda plants at Lisichansk and Slaviansk, the expansion of the Berezniky plant, and the new unit at Volkhovsk built with equipment uprooted from Germany. One of Russia's biggest assets is the 18 billion tons of potash lying in the soil of the Solikamsk area, near Molitov. These, with the potash mines at Wieliczka in Western Ukraine, are more than enough for current requirements. In 1950 700,000 tons of potassium salts were produced. Nitrogen production is also at a high level in Russia and the factories at Dnieprodzerzhinsk, Gorlovka, Stalinogorsk and Stalino are working at top pressure.

Synthetic rubber production in the Soviet Union is climbing rapidly. Before the war it was about 85,000 tons p.a. and in 1950 it had reached 250,000 tons. It is estimated that in 1951 Russian production had reached 300,000 tons. This is a very considerable output and, if the matter is looked at in terms of war potential, the only consolation is that last year American production was at the rate of 750,000 tons. In Russia production has been carried out with potato-derived alcohol as a source of butadiene and both ethylene oxide and acetylene as alternate basic materials for acrylonitrile. Utilising calcium carbide (production at Erivan has topped 60,000 to 70,000 tons annually; that at Kirovakan, 20,000 tons), the Erivan combine alone has been able to supply 75,000 tons of acetylene to the economy, and the relatively new combine at Sungaiti, in Eastern Siberia, is said to be producing more than 25,000 tons of rubber annually using only ethylene as the primary hydrocarbon raw material source.

Although these facts about the Soviet chemical industry are meagre, it is clear that in this field Russia is now second only to the United States, although, of course, the gap in production between the two countries is considerable.

Chemical training and research in Hungary

THE third building of the Veszprém Technical University was recently completed and 520 students are said to be in residence already. Now the main centre in Hungary for training and research in the heavy chemical industry, the university has four main departments, industrial chemistry, mineral oil and coal, electro-chemistry and the refractory industry. All the students study chemistry for the first two years and begin specialisation in the third year of their four-year course. The university laboratories are equipped with a small coking plant, a pitch distillation plant and an oil distillation and refining unit. Further buildings will be completed in the autumn and the main university building, containing lecture rooms, hall and library, will be ready next year.

In the autumn a new building housing the Heavy Chemical Industry Research Institute will be ready for occupation. It is near the university. Work is being carried out on coking processes, the production of phenol from synthesis gas and on the production of cheap chemical fertilisers.

The Hungarian Research Institute for Mineral Oil and Natural Gas, which is claimed to be one of the most up-to-date research institutes in this field in Europe, is also situated near the university. Among other facilities is equipment for low-temperature testing of motor spirit and lubricants.

Sulphuric acid from magnesium sulphate

AT Radebeul, in East Germany, a new process for sulphuric acid production is said to be operating. It seems to resemble the anhydrite process, except that it is based upon magnesium sulphate instead of calcium sulphate, a natural development in East Germany where large amounts of magnesium sulphate are produced as by-products of potash mining and purification. Whereas the anhydrite process gives a calcic by-product that must find its use in the cement industry, the East German process is reported to produce high-quality magnesia.

This difference may give the process considerable economic advantages, for a by-product that has a greater intrinsic value should appreciably reduce the acid production costs. On the other hand, a new large-scale output of technical magnesia will tend to lower the market price for this chemical. It is the age-old problem of heavy chemical process by-products that they are produced in huge quantities; manufacturers of magnesia may well find that the ill wind of sulphuric acid scarcity has chilling consequences for them as well.

Ultra-violet water steriliser

IN spite of scepticism in some quarters of the bactericidal value of ultra-violet light, ultra-violet lamps are widely used to reduce bacterial counts in factories and laboratories where high standards of hygiene are necessary. Ultra-violet lamps are popular in America, a fact that impressed the British pharmaceutical productivity team, not altogether favourably. A logical consequence of this faith in the value of ultra-violet radiation as a bacteria killer is the recent development in the U.S. of an ultra-violet water steriliser.

Known as the Sepco ultra-violet water steriliser, the device consists of a stainless-steel cylinder 6-ft. high by 1 ft. in diameter. Inside are four specially designed ultra-violet tubes standing upright. Baffles at various levels guide the incoming water close to the glowing tubes, thus, according to the manufacturers, 'assuring complete destruction of dangerous bacteria' or, at any rate, producing water to public health standards of purity. Water is processed at the rate of 400 gal. day.

The device has obvious uses in places where the only source of water is a well or a spring. However, it is questionable whether there are many places which have to rely on unprotected sources for water and at the same time have the electricity supply needed to operate the steriliser. In any case, it is doubtful if ultra-violet irradiation is as cheap as chemical sterilisation, although the fact that it produces odourless and tasteless water is something in its favour.

Safety in explosives factories

IN spite of the inherent hazards of explosives manufacture, it is noteworthy that of the 630-odd explosives accidents in Great Britain in 1950, only 175, about one-quarter, actually occurred during the manufacture of explosives. The others happened in handling and using explosives. This is a tribute to the safety measures taken by manufacturers of explosives and also to the research and advice of the Home Office Inspectors of Explosives, whose report for 1950 was published recently. The report contains many examples of the painstaking investigations carried out by the Explosives Inspectors in their efforts to trace the causes of accidents and to recommend additional safety measures suggested by their findings. Such work is sometimes very difficult because the dead victims of the explosions themselves are often the only people who could have provided the necessary information.

One such problem was presented by an accident which occurred during the hand cartridging of dynamite, an operation which had been performed by the firm concerned for 30 years without incident prior to this incident. As the four occupants of the building were killed, the exact cause of the explosion will never be known. There was no direct evidence of what they were doing at the moment of the explosion. There were two Werner Pfleiderer type mixers in the building and time estimates suggest that the mixer for a nitroglycerin blasting explosive known as *Plastex No.* 1 was actually mixing the ingredients while the mixer for another explosive, *Winrox*, was either nearing the completion of mixing or possibly being tipped for emptying. While the more obvious possibilities, such as open lights, sabotage or mechanically defective machinery, could not be entirely

ruled out, they are highly improbable. The special report on the accident, however, arrived at several important conclusions. Firstly, the Werner-Pfleiderer mixers were not entirely suitable for mixing such explosives as were involved in this accident, and in future will not be used by the firm for such work. Secondly, it was recommended that the jelly boxes be reduced in size to allow handling by one man and to do away with the box platform from which the contents were tipped into the mixer. Thirdly, it was pointed out that there was a risk of detachment of pieces of aluminium lining from the wooden boxes and squeezing of explosive between the lining and wood. Further points raised by the report on this accident included the question of adequacy of safety distances, systematic inspection of mixing machines, possibility of sympathetic detonation of ammonium nitrate deposited in the building for subsequent mixing, and systematic clearance of mixed explosives from explosives buildings.

This account typifies the thoroughness with which explosives accidents are investigated and it emphasises the responsibility of chemical engineers and works managers to do everything humanly possible to ensure that the plant and equipment is foolproof. Even with all these precautions, however, there is still the human element to be reckoned with. It is a tragic aspect of explosives manufacture that one lapse from a strict safety code might mean death or serious injury.

Although most of the inspectors' report is concerned with explosives, there are also sections on petroleum spirit accidents and mishaps with petroleum gas and acetylene. Everyone dealing with explosive materials will profit from reading the cautionary tales in this concise and factual report.

Cathodic protection of buried metals

REPLACEMENT of corroded underground pipes is estimated to cost Britain £50,000,000 per year. Cathodic methods of protection as used, for example, on the £2,000,000 oil pipeline from Finnart to Grangemouth in Scotland show promise of becoming an economic and effective way of cutting this bill. Application of the method, however, will only be effective if the fullest possible information on the subject is examined, correlated and made available to all interested bodies. The most suitable body to do this is the British Iron and Steel Research Association's Sub-Committee on the Corrosion of Buried Metals (chairman, Mr. L. C. Whiskin of the Metropolitan Water Board), which has been entrusted by the Minister of Health with the co-ordination of research on this subject.

A standard form for describing cathodic protection installations to safeguard underground pipelines against corrosion in this country has been prepared by the Sub-Committee. It is available from Mr. E. E. White, B.I.S.R.A., 140 Battersea Park Road, London, S.W.11, and is to be returned when completed to the Chemical Research Laboratory of the D.S.I.R., Teddington.

The form, which can be treated as confidential if desired, is in the form of a questionnaire on the protected pipeline and the site in which it is laid, the details of any cathodic protection and the conditions before and after its installation, with details of corrosion failures, repairs, etc.

It is hoped that the form will be widely used to enable the Sub-Committee to obtain a clear picture of the extent and effectiveness of cathodic protection of buried pipelines in this country.

Methanol as an industrial hazard

LIKE all lower aliphatic alcohols, methanol exerts rapid narcotic effects on man. However, it is especially dangerous because it exerts chronic toxic effects also, probably due to the slowness with which it is eliminated from the body and the toxicity of its metabolic oxidation products, formaldehyde and formic acid. Thus there is a definite hazard associated with the now very extensive industrial use of this alcohol.

To ascertain the maximum permissible concentration of methanol in the air compatible with safety, two workers in the Physiology Department of Manchester University, G. Leaf and L. J. Zatman, have carried out laboratory experiments and factory tests, the latter at Imperial Chemical Industries' methanol synthesis plant at Billingham. They found that exposure to a methanol vapour concentration of about 3,000 p.p.m. for 8 hr. day may cause accumulation of methanol in the body and thus give rise to a toxic hazard. Vigorous activity, by stimulating respiration, would probably increase the rate of absorption and the risk of toxicity. For this reason and also because industrial conditions are more difficult to control than those in the laboratory, it is recommended that the permissible maximum concentration of methanol should be one-tenth of the toxic dose, *i.e.* 300 p.p.m.

On this basis, the safety limits which have previously been proposed, *e.g.* 100 p.p.m. by the International Labour Office and 200 p.p.m. by W. F. von Oettingen in the United States, leave a good safety margin.

An interesting aspect of this work which is reported fully in the *British Journal of Industrial Medicine* (1952, **9** (1), pp. 19-31), is that the ingestion of ethanol, together with or shortly after methanol, reduces the rate of elimination of the latter by up to 90%. This is thought to be due to inhibition of the metabolic oxidation of methanol. (Indeed, it is thought that the large proportion of ethanol (up to 90%) in methylated spirits reduces markedly the toxic effects of this alcohol when it is drunk by misguided people.) The favourable effect of ethanol on the course of methanol poisoning might justify attempts to use ethanol therapeutically.

Death of a pioneer

AT the age of 79, Morris W. Kellogg, founder and chairman of the great chemical and petroleum engineering company of the same name, died recently in New York City.

A graduate of Stevens Institute of Technology in 1894, Mr. Kellogg started the company in 1901 as a small pipe fabricating shop in Jersey City. This led to pioneering in the fabrication of penstocks for the hydroelectric power industry. The firm next turned to the manufacture of tanks for storing materials under high pressure and temperature.

From this stemmed the firm's prominent position in the design and construction of petroleum refineries and chemical plants, for it eventually brought about the development of the first hammer-welded stills, a marked improvement over riveted equipment then in use. Today, more than 50 years after its modest start in Jersey City, the Kellogg company is one of the world's leading organisations of its kind.

In late 1944 Mr. Kellogg arranged the sale of the company to Pullman Inc., becoming a director of the parent corporation. He continued active as president of Kellogg until March 1946, at which time he became chairman of the Board.

Organic Chemicals from Natural Gas—I

By R. J. S. Jennings, M.A., A.R.I.C.

In the U.S.A., where vast supplies of natural gas are obtainable, it is hoped to produce significant quantities of useful oxygenated materials from the partial combustion of its methane in the Hydrocol process. This is a modification of the successful German Sachsse process. This paper describes how the chemicals acetone, methanol, formaldehyde and acetaldehyde may be obtained on a commercial scale from natural gas. The following conclusions are reached: (1) The Sachsse, or controlled-oxidation, process is recommended for the ultimate manufacture of acetone, methanol, formaldehyde and acetaldehyde from natural gas. Where only formaldehyde is required (or, if it is not wished to produce formaldehyde from methanol) then partial-oxidation of methane under special conditions may be employed. (2) Acetylene-producing processes which yield large volumes of attendant hydrogen, in addition to acetylene for acetone and acetaldehyde manufacture, are unsuitable for methanol production. (3) When more high-quality methane becomes available from Britain's gas-rich coal seams, dictated by economic conditions, it may be worth erecting a small-scale plant near a colliery for the manufacture of the chemicals discussed.

GREAT interest has been aroused during the last few years in the vast American projects for producing a whole range of oxygenated materials by the controlled oxidation of natural gas. G. Egloff[1] states that in the U.S.A. in 1946, 28% of all organic chemicals were derived from petroleum or natural gas. Several commercial plants in the U.S.A. oxidise natural gas to methanol, ethanol, propanol, formaldehyde, acetaldehyde, acetone, etc. Two commercial plants based on the Fischer-Tropsch process are projected, one of which will use 64,000,000 and the other 100,000,000 cu. ft. of gas/day. In this process (Hydrocol) the natural gas is oxidised at temperatures from 1,480 to 1,540°C. at a pressure of 300 p.s.i. to produce mixtures of hydrogen and carbon monoxide which are then contacted with iron catalyst to produce gasoline, diesel oil and mixtures of oxidised compounds from which alcohols, aldehydes, acids and ketones are recovered.

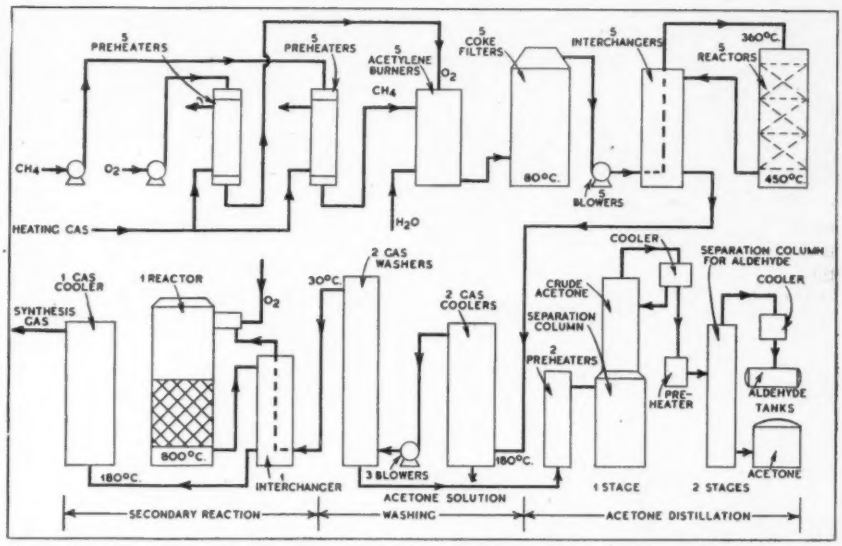
The larger of the two plants is expected to produce about 6,000 barrels of 80-octane gasoline, 1,000 barrels of diesel fuel and over 400,000 lb. of organic chemicals daily. The anticipated annual production of three of the chemicals with which we are concerned is:

Methanol	.. ..	730,000 lb.
Acetaldehyde	.. ..	9,100,000 ,,
Acetone	.. ..	11,200,000 ,,

That the Sachsse Controlled Oxidation process, which depends upon the formation of acetylene and large volumes of synthesis gas, is a preferred method leading to the manufacture of all four chemicals, acetone, methanol, formaldehyde and acetaldehyde from natural gas will be evident from the succeeding pages.

Where only formaldehyde is required, however, this may be obtained by partial oxidation of natural gas under special conditions.

These four chemicals have numerous uses, besides their well-known applications in the laboratory.



Flow sheet for the production of acetone and synthesis gas by the Sachsse oxidation process.

Acetone, a useful solvent, finds an outlet in the manufacture of acrylic resin.

Methanol, useful as a motor racing fuel, is employed in the making of the anti-rust and anti-freeze *Zerone* in America, and is an intermediate for formaldehyde manufacture.

Formaldehyde, widely used in the plastics industry for making thermosetting resins, is also employed in the manufacture of hexamine, an essential intermediate for production of the explosive known as 'R.D.X.' Other uses for formaldehyde include the making of ethylene glycol and pentaerythritol used by the paint and varnish industry. Pentaerythritol tetranitrate is also used as an explosive. Formaldehyde may be converted to phenyl glycine from which the dye indigo can be obtained.

An outlet for formaldehyde is also found in the printing, disinfectant and medical fields. Furthermore, formaldehyde may be made to react with acetylene ultimately to produce butadiene, which with styrene forms the synthetic rubber Buna-S.

Acetaldehyde, used in the old butadiene process, can readily be oxidised to acetic acid, the latter product being used in the manufacture of cellulose acetate for rayon, photographic film, plastics and acetic anhydride.

This paper considers:

1. The conversion of methane to acetylene.
2. The formation of acetone from acetylene.
3. The conversion of synthesis gas to methanol.
4. The production of formaldehyde from (*a*) methanol; and (*b*) methane.
5. The formation of acetaldehyde from (*a*) methanol and acetylene; and (*b*) hydration of acetylene.

1. ACETYLENE FROM METHANE

Production of organic chemicals from acetylene in the U.S.A. is increasing by leaps and bounds. Today practically all acetylene is made by the time-honoured carbide process, but considerable research

has been done on the production of acetylene from natural gas. Recent developments reveal that some of these processes have now reached commercial stature.

Wulff cracking process

The production of acetylene from methane on a pilot-plant scale in a German designed regenerative-type furnace has been described.[2] The process briefly is as follows.[3] The feed gas methane is passed through a regenerative-type furnace heated by combustion of methane. Pressure is reduced to 0.1 atm. Immediately after passage through the furnace the gas is quenched by water sprays to stop further decomposition. The gas enters the bottom of the preliminary scrubber where carbon dust is washed out and the gas is cooled further. The water effluent from this scrubber is subsequently processed after clarification in the diacetylene and acetylene scrubbers, in order to recover dissolved acetylene. The gas is then further cooled by water, compressed to atmospheric pressure, and pumped to a crude gasometer. Further treatments are applied before the acetylene is collected finally in a gasometer.

Further promising pilot-plant work has been carried out by the Tennessee Eastman Corp.[4] These processes operate at lower temperatures (about 1,400°C.) than the arc or internal combustion systems. In the Wulff process studied by Tennessee Eastman, the feed stock is diluted with steam

The Wulff Process Co. has itself just launched a small demonstration unit near Los Angeles operating its process on natural gas to produce 1,000,000 cu. ft. of cylinder acetylene/month.[5] The unit should furnish reliable operating data.

These processes appear economically attractive from the point of view of acetylene production. The German technique of using water scrubbing under pressure is believed to be less economical, because of multi-stage operations and the large size of towers involved, than the use of selective solvents or hypersorption; however, Monsanto is reported to be about to use water scrubbing, possibly because previously acquired knowledge from the Germans will save time.

Electrical production

Arc method. J. P. Lawrie[6] mentions the production of acetylene from natural gas by the German arc method.[7] The gas feed to each arc converter consisted of 50% by volume natural gas and 50% by volume recycle gas.[8] The natural gas contained about 92% by volume CH_4. The recycle gas contained about 85% CH_4, and the balance H_2, N_2 and heavier hydrocarbons. The gas at 1.5 atm. was whirled by vanes into the arc tube. The arc was not constant in position but rotated around in the tube. The terminal temperature of the gas in the tube was 1,600°C. This was cooled immediately to 150°C. by a water spray. At this point the constitution of the gases was:

	%
H_2	55
C_2H_2 (1% diacetylene)	13
C_2H_4	1
CH_4 (other H.C.)	23
CO_2,N_2, etc.	8

The conversion of the gas to acetylene was approximately 50% per pass, with an overall weight yield of 45 to 50%.

The carbon black produced was removed from the product gases by cyclones and water scrubbers. The hydrogen, required for the hydrogenation of aldol to butylene glycol in the old Butadiene process, was purified by low temperature distillation (—180°C.). By this operation it was possible to obtain H_2 with a CO content of less than 0.0001%.

From 100 kgm. of the fresh gas was obtained 45 kgm. acetylene, 9.2 kgm. ethylene, 5.3 kgm. carbon black and 143m³ hydrogen.

It was calculated that the power consumption in the electric arc, per kgm. of acetylene produced, was 9.73 KWh for refinery gas and 11.6 KWh for natural gas. This compares with 9.5 to 11.0 KWh per kgm. of acetylene by the carbide process. At Hüls, Germany, 15 sets of arcs with mercury rectifiers were installed.

Gas purification was effected after passing the cooling spray. The gas was conducted to two cyclones in series in which 60 to 70% of the total carbon black was removed. It was further sprayed with water in a wash tower to remove most of the remaining black and then passed through bag filters to eliminate the residual black.

Higher boiling constituents in the gas were removed by counter-current washing with an aliphatic oil in a series of towers. The gas from the oil washes was washed with water to remove HCN, and then passed through iron oxide boxes to remove S.

After this preliminary purification, the gas was compressed to 19 atm., and absorbed in water in perforated plate towers. The non-absorbed gases, consisting primarily of methane, ethane, ethylene and hydrogen, were passed to the Linde plant where ethylene and hydrogen were separated out and the paraffins were returned to the arc. Acetylene was stripped from the water by four-stage flashing to a final pressure of 0.05 atm. absolute. As the gas from the first stage was too low in acetylene (45%) it was recompressed and recycled through the absorber. The gas from the second, third and fourth flashers was brought together as crude acetylene of 90% purity and further purified.

The crude acetylene was brought up to 97% concentration, with 1% CO_2 and 2% inerts as impurities, by a system of:

(*a*) Low temperature condensation and evaporation using liquid ammonia; and

(*b*) Scrubbing with a petroleum distillate.

This system removed the higher acetylenes. CO_2 was removed by scrubbing the acetylene with caustic solution, giving a final purity of 97 to 98%. This acetylene could then be used for acetaldehyde manufacture, etc.; 6.3 tons of acetylene/hr. were made. G. M. Morrow[8] gives the figure as about 200 metric tons/day.

The above process is described in more detail by D. L. Fuller *et al.*[9] This report contains relevant references, diagrams and flow sheets in great detail (see also [10]).

Schoch process. Since 1942, E. P. Schoch[11] has carried on the development of another electrical process. Instead of an arc, a silent electrical discharge forms acetylene from methane. This system has been employed in a pilot plant processing 1,000 to 2,000 cu. ft./hr. of natural gas. Economic studies indicate that this process would yield acetylene more cheaply than the German arc method. The process consists of four major equipment units, an electric current control unit, a discharge chamber, cyclone and cooler, a unit for the removal of non-acetylene compounds and an acetylene concentration unit.

Temperatures in the discharge chamber are kept below 550°F. Gases drawn from the chamber are freed from carbon and stripped of non-acetylenic compounds. The dilute acetylene is concentrated in the final unit. When using methane as a feed gas, and a 10% acetylene containing product is formed, about one third of the methane in the feed is cracked during its passage through the system, and the balance passes out together with hydrogen and other non-hydrocarbon constituents. The question of disposal of the off-gas is solved by separating the methane from the hydrogen. Very pure hydrogen results.[12] Thus acetylene is produced from natural gas at a concentration of about 10% by this process.[13]

Oxidation

Sachsse process. Dr. Barthelemy was interrogated at Oppau in 1945 on the details of the process for the oxidation of methane with oxygen at high temperatures to acetylene.[10, 14, 15]

At Oppau[14] there were five oxidation units each capable of treating 800m³/hr. of methane. These were coupled to five acetone catalyst units for producing acetone from the dilute acetylene, and the total gas after removing acetone passed through one catalyst unit for the conversion of the remaining 5% of CH_4 before use as synthesis gas.

Eight hundred cubic metres per hour of CH_4 and 400 to 450 m³/hr. of oxygen were preheated separately in *Sicromal** preheaters to 500°C. each, and the hot gases were mixed in a fire-brick lined mixing chamber. The methane was brought into an annulus formed by the top part of the mixing chamber and the oxygen inlet pipe (made of *Sicromal*). In order to achieve adequate mixing, the velocity of gas down

* A chrome-aluminium steel.

The Pros and Cons of the various processes for producing acetylene from natural gas [cf. (13)]

	Wulff	*Arc and Schoch*	*Sachsse*	*Air Oxidation*
PRO	Elimination of electrical power cost. Improvement possible using combination of partial combustion and regenerative stove cracking.	Production of by-product carbon black which may have a use in the rubber industry. Also hydrogen for hydrogenation. Reduced power requirement possible. Thermodynamic calculations indicate a minimum theoretical requirement of electrical energy of 1.8 Kwh./lb. of acetylene as compared with the actual power requirement of about 5.5 Kwh./lb. by both Schoch and German Arc processes.	Elimination of electrical power cost. Production of Fischer-Tropsch synthesis gas as by-product.	Oxygen plant investment is avoided.
CON	Mechanical construction of regenerative stoves is complicated. Maintenance cost will be high. Proposed commercial equipment will involve a unit furnace size 15 times that for pilot-plant scale. Unless the highest temperatures can be reached, a high proportion of ethylene will be obtained, thereby requiring markets for both ethylene and acetylene. Concentration and purification of acetylene is complicated by high proportion of ethylene.	Complicated operation. So far, no electrical process has shown a lower power requirement than the carbide requirement of about 4.5 Kwh./lb. of acetylene produced.	An oxygen plant representing a further substantial investment must be constructed. No substantial pilot plant experience is available on recovery problems which may be met as a result of trace impurities of oxygenated by-products.	Effluent gas is more dilute in C_2H_2, requiring more expensive recovery facilities. By-product gases cannot be used for synthesis unless additional equipment is installed for separation of hydrogen and nitrogen.
Total cost (exclusive of purification) as U.S. cents/lb. of C_2H_2	2.26	6.06	5.90	2.67

the inlet pipe was about three times greater than that down the annulus, and in addition the oxygen was given a spin. The inlet pipe of 25 cm. diameter then enlarged to a rectangular cross-section of 60 × 20 cm. which contained the burner. The firebrick burner block was about 80 cm. below the end of the inlet oxygen pipe, was 60 × 20 cm. thick and contained about 100 8 to 10 mm. holes through which the mixed gases passed at a speed considerably in excess of the rate of propagation of flame in the mixture. The gases burned below this firebrick in a space 10 cm. long and of the same rectangular dimensions as the firebrick burner. The reaction temperature was about 1,400°C. The gases were then quenched to 80°C. by water sprays. The burning compartment was operated at atmospheric pressure, the pressure drop system being about 0.5 m. of water. Carbon gradually accumulated on the underside of the burner and was removed by manual operation of a scraper about once a day.

The burner block was provided with pilot oxygen pipes for starting and maintaining the combusion. The total quantity of oxygen taken by these pilot jets was about 10 m^3/hr.

The action was started by warming up on methane alone to 500°C. A special sample cock was then opened and the issuing methane ignited. The combustion was then carried back to the burner block by inserting a poker carrying oxygen, through the flame of the burner block. The pilot oxygen was turned on and the main stream of oxygen started up slowly. The plant was controlled by the amount of oxygen admitted. If too little oxygen was admitted the reaction fell away and oxygen in the exit gas increased. This was not allowed to exceed 0.1%. If too much oxygen was used, lower yields of acetylene were obtained owing to excessive burning of hydrocarbons.

The volume of exit gas was about double that of the inlet, and it had the following composition.

	%	
C_2H_2	9	
CO_2	5	
CH_4	5	
CO	26	synthesis gas
H_2	52	synthesis gas

The plant had run satisfactorily for two years with practically no renewals, except for the burner, which had to be changed every four to six weeks owing to subjection to high temperatures. It was necessary for the methane to be pure. A small amount of di-acetylene and higher homologues (about 0.1 to 0.2% of the total gas) were also formed, but no attempt was made to remove them. When concentrated acetylene was required the exit gas was compressed to 18 atm. and washed with water.[16]

Carbon was formed to the extent of 1 gm./m^3 of final gas. This was removed by passage through a coke filter. The carbon was of poor grade and was thrown away.

Air oxidation. Partial combustion using air instead of oxygen has also been proposed. Some pilot plant work had been done in the U.S.A. by the Danciger Oil & Refining Co. Higher preheat temperatures were required. Final effluent gases contained only 3.5% C_2H_2, but no oxygen production facilities were required. Both the air and natural gas were separately preheated to 1,500°F. before introduction into the burners. Mixing, combustion, quenching and subsequent cleaning of effluent gas were accomplished similarly to that described for the Sachsse process.[13] It is noteworthy that 99% acetylene can be obtained by the Hypersorption or Solvent Extraction techniques applied to effluent gases from any of the processes described.[13]

Economics of acetylene production from natural gas

Manufacture of acetone, methanol, formaldehyde and acetaldehyde. J. Happel and C. Marsel[13] assume a typical Gulf-Coast natural gas (84% CH_4) as the raw material for production of 20,000,000 lb./yr. of C_2H_2 and its analysis, and that of the effluents from various primary production processes are given in Table 1.

Happel and Marsel give no comparative figures for the Arc process, so let us for this process consider Lawrie's figures,[6]

Table I

Mol. %	*From natural gas*	*Wulff*	*Schoch*	*O_2-Oxidation, Sachsse*	*Air Oxidation*
H_2	—	61.4	42.2	51.3	24.3
N_2	—	—	—	1.6	54.2
CO	—	3.5	2.1	26.3	9.4
CH_4	84.3	22.6	39.2	5.8	3.6
CO_2	4.3	1.5	1.0	5.9	3.5
C_2H_2	—	9.0	9.9	8.5	3.5
Other C.H.	11.4	2.0	5.6	0.6	1.5

which are probably based on Bentheim natural gas used at Hüls[17] of composition CH_4 92%, $H_2S + CO_2$ 3%, N_2 5%. The analysis of the product gases was:

H_2 55%; CH_4 (other H.C.) 23%; C_2H_4 1%; CO_2H_2, etc., 8%; C_2H_2 13% (1% diacetylene).

An examination of the foregoing data from the standpoint of acetone, methanol, formaldehyde and acetaldehyde manufacture from methane leads to the conclusion that, of those processes described, the Sachsse is the only one from which ultimately may be produced all four chemicals; for, although the other methods produce acetylene which may be converted to acetone or acetaldehyde, the Sachsse process is unique in producing vast quantities of synthesis gas necessary for methanol (and hence formaldehyde) manufacture, as well as reasonable yields (8.5%) of acetylene for making the other two chemicals.*

Although the Sachsse method gives the smallest yield of acetylene apart from the air oxidation method, it operates at the highest thermal efficiency. In addition, for the preparation of acetone from acetylene, a gas containing about 8% acetylene gives the best results.[15]

The Controlled Oxidation process, a modification of the Sachsse method, has been selected to supply synthesis gas for the Carthage Hydrocol Inc., Fischer-Tropsch plant at Brownsville, Texas, according to plans announced by P. C. Keith.[18] Estimated raw material requirements have been given as 65,000,000 cu. ft. of natural gas and 40,000,000 cu. ft. of oxygen per day, and it has been said that use of heat from the exothermic synthesis reaction to supply steam to power the compressors will result in a net oxygen cost of only 5 U.S. cents./1,000 cu. ft. The oxygen is to be obtained from air by compression to 75 p.s.i.

According to F. W. Sullivan,[19] the Brownsville plant will yield by-product chemicals amounting to an annual production of ethanol of 63,680,000 lb., acetaldehyde 9,100,000 lb., acetone 11,200,000 lb., methanol 730,000 lb., and acetic acid 24,700,000 lb. among other chemicals. In this process synthesis gas with H_2:CO ratio about 2:1 compressed to 25 to 35 atm. is passed up through a fluidised bed of cheap iron catalyst maintained at 310 to 340°C.

* This is not to say, of course, that the Sachsse process is necessarily the best method for making acetylene from methane.

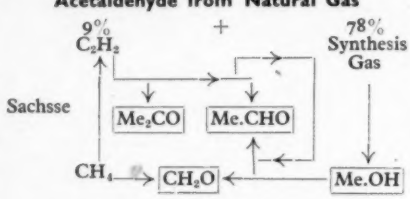
The cost of constructing a Hydrocol plant is about 50% of the cost of a Fischer-Tropsch plant.[20]

M. H. Bigelow[12] maintains that the Sachsse process is extremely interesting from the cost angle and that British investigators were so impressed with its possibilities that it is believed that they have interested one of our large chemical companies in building a unit. Had the process been continued in Germany it appears that it would have found considerable expansion to the detriment of the carbide process.† The Germans succeeded in working out all the critical precautions necessary for its successful operation. They used a dual system of checks based upon infra-red absorption and colorimetric systems. Costs of acetylene made by this process have been quoted at fantastically low prices.

Carbide and Carbon Chemicals Co. are so pleased with their Sachsse process that they are planning a large expansion of the small semi-commercial plant which has been operating at Texas City for over a year.[21]

The economics of the processes described, relating to the production of acetone or acetaldehyde other than by means of the Sachsse Partial Oxidation Method, would be influenced greatly by facilities to dispose of the large volumes of hydrogen produced.

Scheme for Manufacture of Acetone, Methanol, Formaldehyde and Acetaldehyde from Natural Gas



In the second and concluding part of his article, Mr. Jennings will consider the conversion of acetylene to acetone, the conversion of synthesis gas to methanol, and the production of formaldehyde.

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† The price of carbide in England has been quoted as £28 8s. 9d. per ton. Neglecting the cost of acetylene production from carbide, this is equivalent to £70 per ton acetylene; while cylinder acetylene costs 19.7d. per lb., which is equivalent to £184 per ton.

Dehydration of natural gas

Many advances have been made in recent years in the development of new equipment and the modification of old equipment for the dehydration of gases, and in some cases new techniques have been developed which have never been used on a commercial scale before. Many of these new developments have been applied to the drying of natural gas, particularly in the United States, since this industry has expanded considerably since the war, and the growing commercial market has made it necessary to develop more efficient methods and practices.

In a paper recently given to the 44th annual meeting of the American Institute of Chemical Engineers, Mr. J. M. Campbell pointed out that the large majority of all gas dehydrated in America was by dry desiccant plants, glycol absorption or injection plants, expansion refrigeration or low temperature plants. In those natural gas applications where sufficient pressure drop is available between the well and the transmission line, the expansion dehydration or low temperature separation system and glycol injection have been found to give the best results, since not only do they give low effluent dew-points in the unit, but give hydrocarbon condensate recovery up to 35%.

In addition, Mr. Campbell presented experimental curves predicting the temperature drop obtained with a given pressure drop for a natural gas containing various amounts of liquid hydrocarbons, including also experimental data to show that, for horizontal absorber vessels utilising transverse flow, such a vessel in effect extends the capacity of a given weight of bed, since the lower velocity gives better contact near the end of the cycle and the sharp characteristic break-point is not evident. The effect of the glycol concentration on dew-point depression was also shown, an effect of some importance in this field.

Sindri INDIA'S 1,000-TON/DAY FERTILISER FACTORY LAYS THE FOUNDATIONS OF HER HEAVY CHEMICAL INDUSTRY

Near the tiny village of Sindri, in northern India, the biggest fertiliser factory in Asia has been built and is now in operation. The factory is designed to produce 350,000 tons p.a. of sulphate of ammonia, the nitrogenous fertiliser so badly needed to revive and sustain India's impoverished soils. Thus it will produce about one-seventh of the country's ultimate fertiliser needs. Sindri is a Government project. It was designed by an American firm and built by a British corporation with the help of hundreds of British, Indian and American suppliers. Sindri is more than a fertiliser factory, it is the core of heavy chemical production in India and one day it is hoped it will become as big as Billingham, the biggest chemical factory in the British Commonwealth. Here is a description of the four main parts of the factory: the gas plant; the ammonia synthesis plant; the sulphate of ammonia plant; and the power plant. The information is taken from a detailed report prepared by BRIGADIER M. H. COX, O.B.E., M.I.Mech.E., Chief Technical Adviser to the Government of India.

THE first ammonium sulphate was produced at Sindri in October 1951 and the factory was officially opened by the Prime Minister of India on March 2.

The project began in 1943 with an investigation by representatives of Imperial Chemical Industries Ltd. and the Power-Gas Corpn. Ltd. Their findings caused the Indian Government to appoint the Chemical Construction Corpn., of New York, engineers of the project to prepare designs for the whole factory, supervise construction and start production. The Power-Gas Corpn. were appointed chief contractors and asked to supply, in accordance with the designer's specifications, certain special plant of their own manufacture and to act as agents of the Government of India in the procurement of the remaining plant required and to erect it. As much as possible of the plant required was manufactured in India, including all structural steelwork buildings and a considerable tonnage of the simpler plant items. Most of the plant, however, came from Britain and America.

In the foreground is one of the two three-lift spiral-guided gasholders. The building in the background houses the semi-water gas plant which has an output of 33,000,000 cu.ft./day. The three cylindrical towers are the Lymn washers where the gas is washed and cooled. They are 85 ft. high and 11 ft. in diameter. The gasholders and the washers were fabricated in India.

Raw materials

Gypsum. The factory is located in undeveloped country. The site was chosen because it was conveniently placed to receive gypsum, the sulphur-containing raw material, from the North Punjab in empty coal wagons returning to the coal fields. Since then, however, India has been partitioned and these deposits now lie in Pakistan and cannot, therefore, be used. Attempts to find alternative sources in India have resulted in extensive deposits being found in Bikaner. This gypsum is suitable for use at Sindri. Other sources of supply are being developed in Jodhpur where there are big reserves.

Water. The water requirements for the fertiliser factory and its ancillary activities amount to some 12,000,000 gal./day. As the surface flow of the Damodar River was estimated at only 5,000,000 gal./day a reservoir has been built on the Gowai River with a capacity of nearly 1,000,000,000 gal., and an infiltration gallery constructed to tap the water available in the sands in the Damodar bed when the surface supply diminishes.

Coke and coal. For gas making, which is preliminary to the manufacture of ammonia, some 500 to 600 tons/day of coke are required. For the generation of electric power and other purposes coal supplies amounting to about 800 tons/day are required. India has sufficient coal in this region to meet this demand. At present, high-grade metallurgical coke is being used for gas making, but to reduce the drain on India's limited supplies it is planned to install ovens at Sindri for coking second-grade coals.

Gas plant

Coke handling. The arrangements for handling incoming coke consist of an end rock tippler and belt conveyor system. Since it is necessary to stockpile more coke than coal until such time as coke ovens are built at Sindri, the stocking arrangements for coke are somewhat elaborate.

Gas-producing equipment. As a first step in the manufacture of synthetic ammonia, nitrogen and hydrogen must be produced on a large scale from economically available raw materials. In India, coke is available of a quality and at a cost which enables the classical method of production to be employed.

The gas plant at Sindri consists of eight generator units and, with seven generators working, is capable of producing 33,000,000 cu.ft./day of gas when gasifying suitable coke, a typical analysis of the gas being:

	%
CO_2	6.5
COH_2	69.8
CH_4 argon	0.8
N_2	22.9

The Bihar coke has a high ash content, and nearly 500 tons will be needed daily when operating at this load. The net amount of steam required after allowing for production in the boiler jackets will be somewhat more than 500 tons daily.

The gas-making cycle consists essentially of blow and run periods during which the fuel bed is alternately heated up by the introduction of air alone and cooled during gasification. A complete cycles takes 3 to 4 min.

The gas is delivered from the gas collecting main to three gas washing and cooling towers, where it passes upwards countercurrent with a stream of cooling water. In its downward passage the cooling water passes over a number of alternate cones and discs to ensure intimate contact with the gas. Nearly 200,000 gal./hr. of cooling water is in circulation through the gas-washing system and is recirculated through a settling tank and over a cooling tower so that only a relatively small make-up quantity is necessary. Equipment is provided for the addition of soda ash solution to the system for partial removal of H_2S at the same time as the gas is washed and cooled, according to a patented wet washing process. Three circulating pumps are provided, one for pumping from the cold well to the top of the gas washers, one for pumping from the hot well to the top of the cooling tower, and the third installed in such a way as to act as a standby for either duty. The cooled washed gas is delivered to a raw gas holder of 500,000 cu. ft. capacity, which acts as a buffer to absorb any variation in the rate of gas production and rate of delivery through subsequent processes. The gas holder, which is of the spiral guided type, is approximately 100 ft. in diameter by 100 ft. high when its three lifts are fully extended. Alarm and shut-down equipment is installed to operate when the contents of the gas holder reach approximately 90% or, on the other hand, drop to approximately 10% of its full capacity.

Throughout the whole plant special attention has been paid to instrumentation, so that operating personnel may be in a position to run the plant with the highest degree of efficiency.

A particular feature about the gas plant is the large amount of equipment fabricated in India, which includes the cylindrical steel Lymn washers 85 ft. high and 11 ft. in diameter, the raw gas holder 102 ft. in diameter, and converted gas holder 92 ft. in diameter, each three lift and 90 ft. high at maximum lift, the sulphur-removal boxes all low- and medium-pressure units in the CO conversion plant with the exception of heat exchangers, etc.

Ammonia synthesis plant

The ammonia synthesis plant consists of six main sections: (1) compression section, (2) CO_2 removal section, (3) gas purification section, (4) ammonia synthesis section, (5) refrigeration section and (6) ammonia weighing and storage section. The complete plant is housed in a U-shaped, steel-framed, asbestos-cement sheet clad building with a reinforced concrete floor at the 15-ft. level. The building is 66 ft. high and covers a floor area of 5,300 sq. ft. The main building contains 1,725 tons of steel. In addition, 75 tons of steel were used in ancillary buildings. A considerable amount of equipment such as scrubbing towers, etc., is positioned outside the building in the open air.

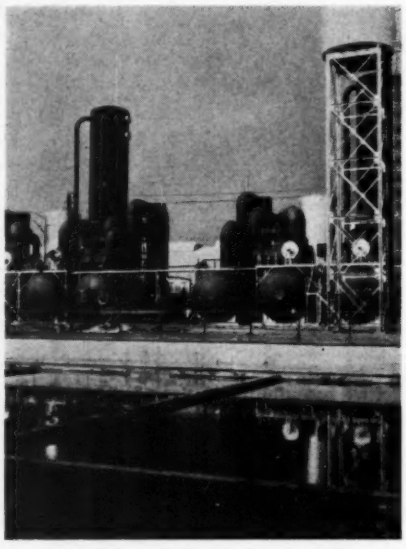
For servicing the installed plant the interior of the building is equipped with six overhead travelling and traversing cranes.

Compression section. The compression section serves sections (2), (3) and (4) above, because the compressors installed are of the six-stage type. CO_2 removal is effected after the third stage of compression. Gas purification is effected after the fifth stage of compression. Conversion is effected after the sixth stage of compression when the gas is at 5,200 p.s.i.

In the compression section there are eight horizontally opposed, staggered cylinder, six-stage compressors, each directly coupled to a 3,300-V synchronous motor of 2,750 h.p. running at 300 r.p.m.

The compressors are located at the 15-ft. floor level, intercoolers and all auxiliary equipment being located below. The compression foundations consist of massive reinforced concrete blocks with a gap between blocks and the floor at the 15-ft. level. The blocks, in turn, are mounted on rafts.

The compressors are 14-in.-stroke, five-throw, six-stage, direct-connected, motor-driven units.



The carbon monoxide conversion plant, part of the installation supplied by the Power-Gas Corp. Ltd.

The composition of the gas at this point is:

	Volume
CO_2	8%
CO	31%
H_2	39%
N_2	22%
Methane	—
Argon	—

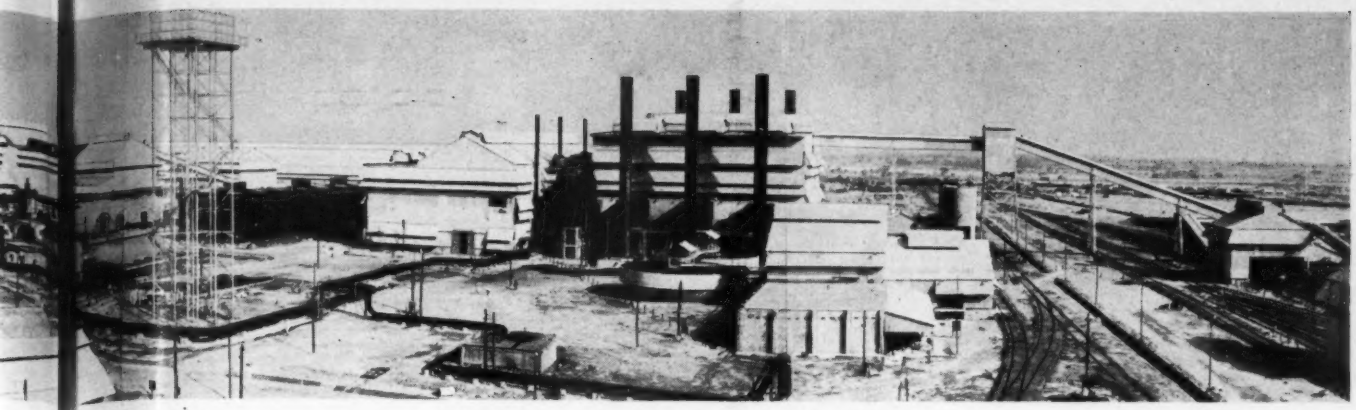
As the gas passes through the six stages the various gases are removed, leaving only hydrogen and nitrogen, the combination of which produces ammonia.

CO_2 removal section. The CO_2 removal equipment, strictly speaking, is part of the gas plant supplied by the Power-Gas Corpn. Before CO_2 removal the gas has to go through three stages of compression. The gas from the third stage of the compressors is passed upwards through Raschig-ring-packed scrubbing towers against a countercurrent stream of water, and CO_2 is removed by dissolving the gas in the water. The scrubbing towers, of welded construction, are 73 ft. 3 in. high and 8 ft. in diameter and weigh 65 tons each.

Circulation of water through the scrubbing towers is effected by centrifugal pump units each centrally mounted on a bed plate and directly coupled to an electric motor at one end and a water turbine at the other.

Gas purification section. After the fifth stage of compression, gas washing is carried out with ammoniacal copper solution to remove CO and some CO_2 and then by caustic solution to remove the rest of CO_2. The copper solution is circulated through the scrubbing tower, absorbing carbon dioxide and carbon monoxide, and then through the regenerating system where the gases are driven off and returned to the CO oxidation plant. The ammoniacal copper solution is cooled for re-use in the scrubber. The caustic washing solution is not regenerated; it is recirculated until spent and then passed for use in the gas plant.

Ammonia synthesis section. The gases, purified as described above, are returned to the compressor at the fifth stage. After passing through the sixth



View of the Sindri factory from the gas plant showing the sulphate and power plant sections.

stage of compression the gases at approximately 5,200 p.s.i. are passed to the ammonia synthesis section.

The synthesis system, the fundamentals of which are high pressure, elevated temperature and catalytic action, produces liquid anhydrous ammonia by the 'N.E.C. process,' employing the latest developments and improvements of that process. The conversion section is rated to give a total production of 270 tons day. The carefully purified compressed nitrogen-hydrogen mixture is delivered to the synthesis system and mixed with the gases in circulation at the discharge of the circulators at a point where the greater part of the ammonia has already been condensed from the gas in circulation. After removal of any oil introduced into the gas by the lubrication of the compressors or circulators, the gas mixture passes through a condenser and is cooled to effect a final condensation of ammonia from the mixture of make-up gas and circulating gases.

The condensing ammonia has a great affinity for water and acidic compounds and the purification thus effected removes the last traces of such impurities as would constitute catalyst poisons. Leaving the condenser, the gas mixture enters the ammonia converter containing the N.E.C. construction of heat exchanger and catalyst. The converter arrangement is such that the pressure-sustaining walls are maintained always at a temperature only slightly above ambient, while the temperature of the catalyst is kept at a constant optimum. By this means overheating of portions of the catalyst mass with consequent loss of activity is avoided.

Leaving the converter, the gases are cooled, the greater part of the ammonia content is removed as liquid anhydrous ammonia and the uncondensed gases pass to the circulator and are recirculated through the system.

Refrigeration section. This contains all the equipment necessary for the supply of refrigeration for both the regenerated copper solution in the purification section and the ammonia-cooled condensers in the synthesis section. The equipment includes five ammonia compressors driven by direct-coupled 500-h.p. electric motors, together with the ammonia condensers and all connected equipment.

Ammonia weighing and storage section. The anhydrous ammonia bled off from the ammonia synthesis system is passed to the weighing and storage section.

Two horizontal measuring tanks are provided for measuring the quantity of ammonia produced. A let-down tank is provided for the reduction of pressure of the ammonia from the synthesis system. Gas which is dissolved in the liquid ammonia under synthesis pressure is relieved by this pressure reduction and carries off some ammonia in gas form. This gas passes to a recovery system where the ammonia content is absorbed in water to form aqua ammonia, which is fed to the sulphate plant where it is added to the carbonators. The waste gas is fed into a fuel gas system for use in the sulphate plant and any excess gas is burned in the boilers.

Liquid ammonia is sent from the measuring tanks to large spheres for bulk storage. Spherical vessels are used because they represent the most economical use of steel.

Sindri facts and figures

Total yardage of reinforced concrete, including the silo	91,000 cu.yd.
Tonnage of structural steel in the factory	11,000 tons
Tonnage of plant in the factory	45,000 ,,
Installed capacity of power house	80,000 kW
Pipelines in the factory and building for distribution of steam, water and gas (varying in size from the smallest size to 72-in. bore)	80 miles
Belt conveyors in the factory	7 ,,
Electric power cables in factory	170 ,,
Railway track in the factory and marshalling yard	12 ,,
Consumption of water and full expansion	12,000,000 gal./day
Refrigeration for gas cooling and air-conditioning equivalent to	3,500 tons/day of ice
Gas generated	33,000,000 cu.ft./day
Anhydrous ammonia manufactured	300 tons/day
Outgoing finished products:	
Ammonium sulphate	1,000 ,, ,,
Cement	300 ,, ,,
Incoming raw materials handled:	
Coal	800 ,, ,,
Coke	600 ,, ,,
Gypsum	1,800 ,, ,,
Other raw materials	400 ,, ,,
Outgoing by-products and waste:	
Calcium carbonate sludge	900 ,, ,,
Ash	300 ,, ,,

Two additional measuring tanks are provided for distributing the ammonia to the consuming department.

A recompression system is provided to control the pressure in the storage tanks.

Ammonia synthesis equipment. This is of special interest, particularly having regard to the super-high operating pressures. The CO_2 scrubbing towers are built to a Class 'A' welded construction standard. The pumps for the supply of water to the scrubbing towers are the Harland Duoglide twin-stage centrifugal type. The alternating-current electric motors are the Harland high-efficiency drip-proof type continuously rated at 1,450 b.h.p. The Francis water turbines operating on the let-down pressures of the water develop 575 h.p. Fully-automatic level-control equipment has been provided to ensure that the water level in the scrubbers does not fall to a point where gas is passed through the turbines.

The scrubbing towers in the purification section are hollow forged vessels machined all over. The ammonia converters are hollow forged vessels of exceptionally heavy weight and machined all over. The production of these large forgings entails the use of plant of exceptional size and capacity.

The pumps for recirculating the ammoniacal copper solution against a pressure of 1,800 p.s.i. are 25-stage centrifugal pumps of special design. The ammonia weighing tanks and let-down tanks each have a capacity of 25 tons of liquid anhydrous ammonia.

The two Horton spheres are of particular interest. They are 45 ft. 8 in. internal diameter and have a wall thickness of $\frac{7}{8}$ in. and are designed to operate at a maximum working pressure of 50 p.s.i. The shaped plates, bevelled ready for welding, were delivered at Sindri and the spheres were site-welded. Each sphere weighs empty 145 tons and has a storage capacity of 800 tons of liquid anhydrous ammonia, or a total storage capacity of 1,600 tons for the two spheres. The spheres are lagged with cork to ensure maintenance of normal storage temperature of 30°F.

Sulphate plant

The sulphate plant consists of eight main sections as follows: (1) materials handling section, (2) gypsum crushing and grinding section, (3) carbonation section, (4) reaction and filtration section, (5) decomposition section, (6) evaporation, filtration, drying and cooling section, (7) storage silo and (8) package and despatch section.

Materials handling. For handling incoming gypsum the material handling section of the sulphate plant is equipped with an end rock tippler and a conveyor system, as in the case of the power plant and gas plant. The conveyor system is designed to deliver gypsum direct to the crushing mills or to stockpile as may be required.

The stockpiling arrangements in the sulphate plant differ from the arrangements in the power plant and the gas plant in that the gypsum stockpile is housed under cover to keep it dry, because wet gypsum would give rise to difficulties in the crushing and grinding mills.

The gypsum is housed in a steel-framed asbestos-cement sheet clad building, 70 ft. high, 600 ft. long and 125 ft. wide. The building when full will hold 90,000 tons of gypsum or approximately seven weeks' supply at full output.

Crushing and grinding section. Gypsum from either incoming rail wagons or from stockpile, sized to 8 in. or less, is delivered to the gypsum-crushing building. The building contains two Pennsylvania impactor hammer mills for crushing the gypsum.

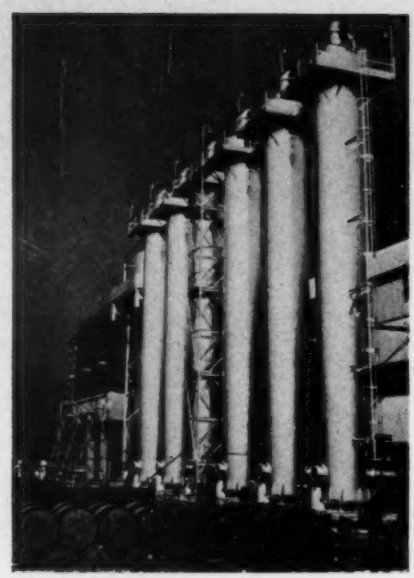
The gypsum-grinding building houses eight Lopulco-type grinding mills, each capable of producing 11 tons/hr. of ground gypsum from raw material passing through a screen 1-in. mesh. These units produce a product of extreme fineness for use in the reaction process.

It may happen that the gypsum as delivered to the mill contains free moisture to such an extent that the mill would be unable to function and, to meet this eventuality, a gas-fired furnace is incorporated in the grinding system so that the products of combustion from the furnace are drawn into the mill system where the heat content is utilised to evaporate the moisture, in other words the product being ground is dried in the mill.

Apart therefore from the adventitious inleakage of air, due to the operation of the system under suction, it is necessary to ensure that the whole of the milling system must remain above the dewpoint and the moisture-laden air must be purged from the milling system. A separate fan with damper control is supplied for this purpose.

From the gypsum-grinding section the ground gypsum is sent by belt conveyors to the roof reception point of the reaction and filtration section.

Carbonation section. In the carbonation section the CO_2 gas recovered at the CO_2 removal section in the gas plant/



Six carbon dioxide scrubber towers wash the stream of converted gas under a pressure of about 300 lb./sq.in. The towers are 75 ft. high, 8 ft. in diameter and weigh 65 tons each.

ammonia synthesis plant is reacted with aqua ammonia made up of ammonia from the ammonia synthesis plant and water. The plant in this section is mainly of aluminium and stainless steel. Most of this plant is located in the open.

Reaction and filtration section. The reaction and filtration plant is housed in a steel-framed asbestos-cement-sheet-clad building 62 ft. high, 180 ft. long and 164 ft. wide. The building contains two upper floors. Most of the large and intricate plant is built into the building structure. For servicing the installed plant the building is equipped with an overhead travelling and traversing crane of 15 tons capacity.

Calcium sulphate (gypsum) from the grinding mills is fed into the ammonium carbonate solution in a series of reactors. Double decomposition takes place, the result being ammonium sulphate in the form of liquor and calcium carbonate in the form of an insoluble precipitate. The reaction vessels are fitted with mechanical stirrers and are steam-heated. From the reaction vessels the magma is piped to a distribution tank, from where it is fed to a series of filters.

Chalk is removed from the sulphate of ammonia solution in two stages, using *Endflow* filters. These machines, with the exception of the main trunnion bearings, are constructed entirely in stainless steel. The liquor direct from process is dealt with in the primary filters, from which the filter cake is washed by filtrate from the secondary filters. The cake discharge from the primary filters is repulped, also with filtrate from the secondary filters, and then followed by the secondary filtration stage in which the washing is carried out with fresh water.

There are four filters each in the primary and secondary stages and it is intended that three machines should in each case be capable of dealing with full production, leaving thus one machine as a standby.

The filtered liquor still contains some chalk particles which are settled out in large stainless-steel settling tanks fitted with the necessary equipment for draining off settled liquor and removal of settled-out chalk automatically.

Decomposition section. The clear liquor from the settlers contains some free ammonia and CO_2 which is stripped from the solution in the decomposition section, the ammonia and CO_2 being absorbed in water and sent back to the carbonation section to be recycled. The plant in the decomposition section consists mainly of a series of stripping and absorbing towers together with their heaters and coolers.

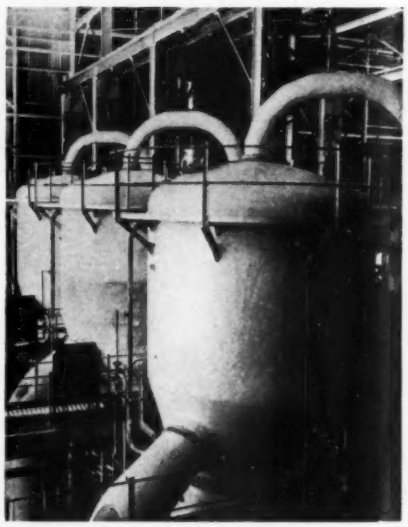
Evaporation, filtration, drying and cooling section. This large section is housed in a steel-framed asbestos-cement-sheet-clad building 95 ft. 6 in. high, covering an area of 48,250 sq. ft. This building has five floors and contains 4,500 tons of steel. The building is equipped with three overhead travelling and traversing cranes of 10-ton capacity.

From the decomposition section the ammonium sulphate liquor is passed to a series of multi-effect *Krystal* evaporators where the excess water is driven off and crystals of ammonium sulphate are formed.

The multi-effect evaporators installed at Sindri are the largest of their kind in the world.

To achieve the output of 350,000 tons of sulphate crystals annually the daily consumption of the plant amounts to 3,000 tons of feed solution, 600 tons of exhaust steam, 5,350,000 gal. of cooling water for the condenser and 7,200 kW of power for circulating and regulating pumps.

The *Krystal* crystalliser process, because



The nine stainless-steel vessels of the 'Krystal' evaporator installation stand 40 ft. high and are capable of producing 1,000 tons/day of ammonium sulphate crystals.

A general view of the synthesis section. The two Horton spheres are 45 ft. 8 in. in internal diameter and have a wall thickness of $\frac{7}{8}$ in. They were site-welded.

of its ability to control both the size and shape of the crystals, produces a uniform product. This uniformity of crystals results in lower drying costs and drier crystals. During storage there is less tendency to cake and the farmer's troubles due to the clogging of his drills are minimised.

The installation consists of three sets of three vessels, making nine vessels in all, each with an external heat exchanger, liquor circulating pump, liquor and vapour lines.

Each vessel is of stainless steel construction and comprises two main parts. The upper part where evaporation takes place is called the vaporiser, and the lower part, where the crystals form and grow, the suspension container. The vaporisers are 12 ft. 6 in. in diameter, the containers 14 ft. 6 in. in diameter and when mounted one above the other are 40 ft. high overall. A special feature of the containers is that the lower internal surface of the stainless steel is polished in order that the caking of crystals to the metal surface may be eliminated.

Fitted inside the suspension container is a central pipe which guides the supersaturated liquor from the vaporiser (where supersaturation occurs) to the suspension container in which there is a dense suspension of crystals. The supersaturation is released upon the crystal suspension, causing it to grow, and as the crystals sink to the bottom of the vessel, due to their increased weight, they are removed from the vessel through a salt catcher, which is a small vessel attached to the underside of the main vessel.

The pumps circulating the liquor in the vessels are specially designed so that they do not crush any of the crystals which may circulate through the system. These pumps circulate nearly 500,000 gal. hr. of liquor, the circulation being controlled by a butterfly valve fitted in the liquor pipeline.

A complete set of instruments has been provided with the installation and they have been so arranged that easy operation is ensured. The instruments are mounted close to the evaporator vessel to which they refer and are supplemented by distance recording potentiometers and pressure recorders on a central panel.

The crystal slurry removed from the evaporators is transferred to vacuum filters where the mother liquor is separated from the crystals. The mother liquor is returned to the evaporators, the wet crystals being fed to large rotary dryers. Drying is effected by passing hot inert gas through the dryers. Cooling is effected by a similar battery of rotary coolers by means of air drawn through the coolers. Any sulphate dust carried over by the air stream is separated out by means of cyclone separators and returned to the belt conveyor. From the delivery end of the coolers the sulphate is transferred to a belt conveyor which in turn discharges on to an inclined conveyor which delivers the dried and cooled product to the silo or the bagging plant direct as required. The inclined conveyor is fitted with a weigher to record the amount of sulphate produced.

Storage silo. The storage silo is a building of unique construction. To maintain the stocks needed to balance supply and demand under all forseeable conditions, storage is provided for 90,000 tons equivalent to three months' production at maximum output. The silo is a reinforced concrete building 660 ft. long, comprising 22 independent arch sections each 30 ft. long spanning 143 ft. between abutments and having a rise of 82 ft. to the crown.

Bagging and despatch section. This section has to deal with 1,000 tons/day of ammonium sulphate. If it was packed in 2 cwt. bags this would involve 10,000 bags/day. Actually the number will be greater than this because some is filled into smaller packs.

Empty bags are received in the ground floor section. Here they are unpacked and passed through the bag printing section where they are branded to show contents when filled. Branded bags are then conveyed by an elevator to the filling floor.

Ammonium sulphate, either from process or the silo as required, is delivered by belt conveyor to the roof bunkers of the filling section.

Instrumentation

The modern concept in chemical engineering is continuous instead of batch production and this has been applied at Sindri. Some of the control problems thereby introduced are:

(*a*) To measure, clarify and condition the millions of gallons of water used each day for boiler feed and process work.

(*b*) To measure and control the millions of pounds of steam used each day.

(*c*) To measure, and at the various stages control, the composition of some 33,000,000 cu. ft. of gas per day, within extremely close limits, especially as regards the composition of the gases.

(*d*) To measure and control steam and gases of pressure varying from absolute vacuum to pressures of up to 6,000 p.s.i.

(*e*) To measure and control complex liquid solutions.

(*f*) To measure and control temperatures.

(*g*) To maintain and control the levels of liquids in vessels.

(*h*) To measure and record the generation and consumption of electric energy throughout the plant.

(*i*) To weigh or measure solid raw materials and finished products at various points in the plant, including the continuous weighing of material carried by fast-moving conveyor belts, in quantities amounting to thousands of tons per day.

The factory incorporates 1,000 indicating pressure gauges of all types, 300 recording controllers for process control, 350 recorders of various types, 150 alarm instruments of various types, 20 gas analysers, 50 level indicating controllers and 2,000 electric control and recording instruments of various types, a total of some 3,870 instruments.

The installation of this equipment involved the use of several miles of medium- and high-pressure tubing and several miles of multi-core electrical cables.

Power plant and process piping

The piping in the factory falls into three main groups, namely power plant piping,

super-high-pressure piping and process piping.

The power plant piping consists mainly of high-pressure piping totalling 670 tons in weight. These pipes were imported already manipulated into the intricate shapes necessary for connecting up a complete range of six boiler units with a complete range of turboalternators. The process pipe-work system of the Sindri factory comprises about 80 miles of pipes of all sizes from 6 ft. in diameter down to $\frac{1}{8}$ in. in diameter.

Acid proofing of floors and walls

In some of the structures at Sindri there is a danger of the concrete being attacked by chemicals. It was decided that the floors and walls of such structures would be treated with a chemical-resistant bituminous treatment. Except for some special grades of blown bitumen all the products used in this work were made in India from Indian raw materials.

The area of the different works executed at Sindri amount to:

	Surface area (sq. ft.)
Pipe coating	112,063
Roof waterproofing	47,125
Chemical proofing:	
Floors	76,916
Walls	55,933
	292,037

This represents a total area of nearly 7 acres.

Water cooling

Mention has already been made of the water supply arrangements. To conserve water, full use must be made in the factory of water-cooling equipment to remove the heat from water in circulation and return it to service.

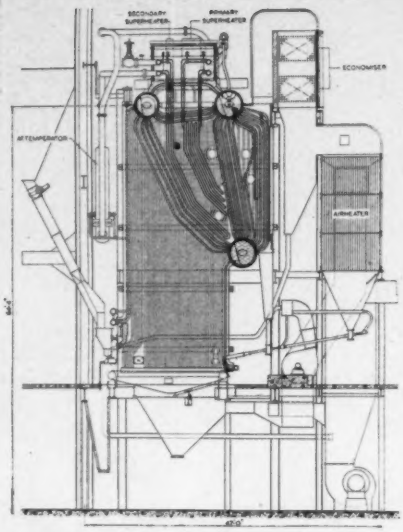
The choice of cooling equipment lay between reinforced concrete towers with wooden grids and all-wood towers. After full consideration of all the factors involved it was decided to plan for wooden cooling towers.

The make up for the water in circulation of the factory, which excludes the supply for domestic and sanitary purposes in both the factory and townships, amounts to approximately 5,800,000 gal./day. Compared with this amount, water in circulation over the cooling towers amounts to 648,000 tons/day. It was for removing the heat from the great volume of water that the cooling towers had to be designed.

Seven cooling towers were installed consisting of a total of 37 cells for service as shown in Table 1.

Table 1

Service	*Capacity gal./min.*	*No. of cells*	*Overall dimensions in feet*
Power plant ..	55,200	18	289.5 × 57.5
Ammonia synthesis	24,000	8	129.5 × 65.5
Gas plant	3,600	2	57.5 × 29.5
Ammonium sulphate			
Misc. service ..	2,400	1	33.5 × 33.5
Jet condenser ..	6,000	2	65.5 × 33.5
Carbonation plant..	4,925	2	57.5 × 33.5
Degasifying ..	36,000	4	65.5 × 56.5



Sectional drawing of one of the tri-drum boilers supplied by Babcock & Wilcox Ltd.

The towers are mechanical induced-draught type design on the counterflow principles. In order to withstand the most adverse conditions which may prevail for the services encountered, the towers are constructed of heat-grade California redwood with corrosion-resistant hardware. The structures are designed for 100-m.p.h. wind and earthquake factor of 0.2 g.

The casing is of double wall construction with tongue-groove redwood sheathing. Water distribution system is of the gravity type. Each drive assembly, consisting of one axial flow fan, totally enclosed fan-cooled motor and right-angle worm gear, is mounted on a heavy structural steel frame. Large reinforced concrete basins are constructed over the cooling towers.

Power plant

All power for the factory is supplied by a new thermal electric power station. Most of the Bihar coal mines are operated by electric power and the Bihar government had intended for a long time to erect a large thermal station in the coal fields with a grid distribution system. The site chosen for the station was at Sindri and after the fertiliser factory had been planned it was decided to build an 80,000-kW power house to supply the factory and the proposed Bihar power grid. The normal power plant load of the factory is 40,000 kW, including power plant auxiliaries, and 13,000 kW is required for the grid. It also provides 300,000 lb./hr. of steam at 25 p.s.i.g. and 23,000 lb./hr. of boiler feed water for the gas plant generator jackets.

Boilers. Six coal-fired steam generators furnish steam for power generation and for process use. The boilers are three-drum type, bent tube with water-cooled furnace walls, bare tube superheaters, bare tube economisers, cross-flow tubular air heater and multi-cyclone dust collectors.

Firing is by forward travelling grate, double-unit Detroit *Roto-stoker* type. Gas fuel burners are provided in No. 5 boiler to utilise waste gases from the ammonia synthesis plant. Superheat control is by interstage external automatically controlled attemperator. One forced-draught and one induced-draught fans and two secondary air fans are provided per boiler. All secondary air fans are motor driven. Forced-draught and induced-draught fans on boilers Nos. 1 and 3 boilers are steam driven. Steam-driven fans are of variable speed. Motor-driven fans are constant speed with vane and damper control.

Fly ash or grit from all collecting points in the boilers can be refired at the back of the furnace by aid of the secondary air fans. Ash from the dust collectors, gate sifting and grate discharge are removed by the ash handling system.

The design conditions are: outlet steam, 650 p.s.i.g., 830°F.; inlet steam, 650 p.s.i.g., 320°F.; normal rating, 140,000 lb./hr. steam; maximum continuous rating, 175,000 lb./hr. steam; and fuel consumption, 140,000 lb./hr., using 18.5% ash coal.

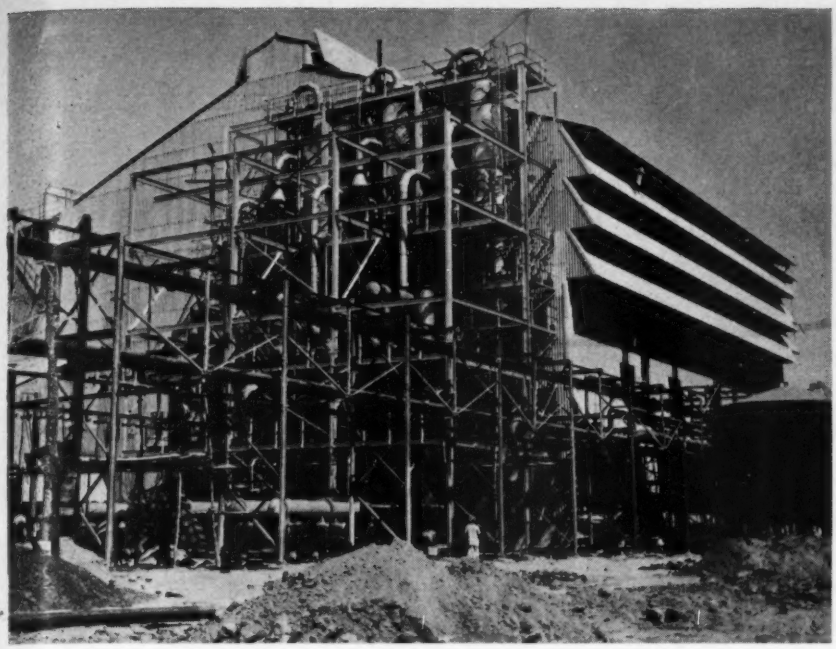
The water conditions specified are with 3,000 p.p.m. of total solids in boiler drums; the makers guarantee solids in steam will not extend 1 p.p.m. Continuous blow-down to maintain 3,000 p.p.m. depends on feed water conditions, etc., but design is based on 10% blow-down. Phosphate feed to boiler drums and sulphite feed to boiler feed suction is provided as supplementary feed water treatment.

There are two 12,500-kW back-pressure and four 15,000-kW condensing turbo-alternators. All six alternators generate three-phase current at 11,000 V, 50 c/s.

Fire protection. In view of the climatic conditions, the control room containing all the main station electrical controls is air conditioned. A carbon dioxide fire-protection system is also provided for all the oil-fired switch gear in the three main switch rooms, the generator neutral switch compartments and also for the generators.

Water softening and clarification. Water for both boiler and process use is softened in a cold lime softening plant and clarified using sodium aluminate as a flocculent. All cooling in the plant is done in closed-circuit cooling towers and the tendency of the lime-treated water to scale is controlled by the addition of acid.

Water is pumped from the Damodar river to a large tank which has a capacity of 80,000,000 gal. and functions both as a settling basin and a local reserve reservoir. The clarification plant is designed to deal with 7,000 gal./min. of water and the main acid dosing plant with 5,350 gal./min.; the subsidiary acid dosing plants for treating the water to the cooling circuits are designed to deal with 980, 480 and 200 gal./min. respectively.



The decomposition plant where excess ammonia and carbon dioxide are recovered.

Softening and clarification of the water is effected in an accelerator plant, the design of which enables a tank of under 1½ hr. capacity to be used. With the accelerated reaction system the incoming raw water and chemical reagents are mixed and circulated with a bed of sludge previously formed in the base of the tank, which accelerates the chemical and physical reactions and enables equilibrium to be obtained in a matter of minutes, thereby reducing the reaction time required for complete clarification. With the accelerator it is possible to obtain water having a turbidity of 10 p.p.m. or less.

From the storage reservoir the clarified and softened water is pumped to the various cooling circuits for make-up purposes, but before entering the circuits further acid is added to reduce the *p*H to a figure most suitable for the circuit in which the water is used. As mentioned above for treating the main body of water the quantity of acid added is controlled from the *p*H of the water, but for the individual cooling circuits the quantity of acid added is regulated by the quantity of water flowing to the particular circuits. Venturi tubes are fitted in the make-up supplies to the three circuits and the quantity of water flowing operates chemical measuring and injection pumps which deliver strong acid from feed tanks to points of application in the respective circuits; a *p*H recorder is provided for each cooling circuit to give a chart record of the *p*H of the water in the particular circuit.

Boiler feed water treatment. The feed to the boilers consists of returned condensate and make-up from the clarification plant. The total feed required is 1,000,000 lb. hr., returned condensate normally amounting to approximately 50% of this figure.

The feed water heating and treatment systems consist of four major interrelated equipment groups as follows:

(1) Hot process softener system for treatment and de-aeration of make-up for power plant boiler and generator jackets of the semi-water gas plant.

(2) De-aerators for condensate from condensing turbo-generators.

(3) Feed water supplementary treatment.

(4) Closed feed water heaters.

Pumps. All pumps have constant-speed across-the-line-starting electric motor drive except for two of the four main boiler feed pumps which are steam turbine driven. All pumps are centrifugal except for the chemical feed pumps and sludge pumps on the hot process softeners and the chemical feed pumps on the sulphate and phosphate supplementary water treatment, which are plunger pumps. Chemical feed pumps to softeners operate intermittently by automatic control from flow of untreated water to the softeners. Sludge pumps normally operate continuously, except when water to be treated does not require sludge recirculation. The supplementary chemical feed pumps operate continuously with manually-set stroke control to give necessary feed as determined by water analysis to maintain an excess of both sulphite and phosphate.

Ash handling. The coals used have ash contents ranging from 18.5% to 35%. The ash handling equipment has sufficient capacity for use of coal to the upper limits of 35% ash at full boiler rating. Ash quantity to be handled may be as high as 400 long tons day with 35% ash and full factory operation.

Control of steam generating units is by a complete automatic combustion control system.

Suppliers

Centrifugal oil purifiers: Alfa-Laval & Co. Ltd.
Krystal evaporator plant, primary and secondary heat exchangers, water saturators, co-oxidation converters and miscellaneous tanks: Ashmore, Benson Pease & Co. Ltd.
Valves and plug cocks: Audley Engg. Co. Ltd.
Boilers and filtration building crane: Babcock & Wilcox Ltd.
Pressure controllers, test pumps, valves, etc.: W. H. Bailey & Co. Ltd.
Valves: Blakeborough & Sons Ltd.
Converter heat control units: British Thomson-Houston Co. Ltd.
Gas pressure controllers, etc.: British Thermostat Co. Ltd.
Stainless-steel tubes: British Iron & Steel Corpn. Ltd.
Special liquor pumps: British LaBour Pump Co. Ltd.
Designers of ammonium sulphate storage silo: Cementation Co. Ltd. (constructed by J. C. Gammons).
Chalk settler mechanism and primary and secondary chalk repulpers: Dorr-Oliver Co. Ltd.
H.P. instrument valves, instruments, safety equipment, recording flow meters, etc.: Foxboro-Yoxall Ltd.
Valves: Glenfield & Kennedy Ltd.
Filters for chemical feed pumps: Haughtons Metallic Co. Ltd.
Pressure switches: Honeywell-Brown Ltd.
Aluminium and stoneware Raschig rings: Hydronyl Syndicate Ltd.
Agitator units: Kestner Evap. & Engg. Co. Ltd.
Lionweld flooring: Lionweld Ltd.
Level controls, etc.: Londex Ltd.
Water and special liquor pumps and sprinkler system for bag storage building: Mather & Platt Ltd.
Preheaters and reboilers: Metal Propellers Ltd.
Filter presses: Manlove, Alliot & Co. Ltd.
Pressure vessels: Oxley Engg. Co. Ltd.
Ammonia refrigeration compressors: Peter Brotherhood Ltd.
Chief contractors, gas producing plant: Power-Gas Corpn., Ltd.
Water and special liquor pumps: Pulsometer Engg. Co. Ltd.
Gypsum-feed weighing machines and bag filling and weighing machines: Richard Simon & Sons Ltd.
Wagon tipplers, wagon hauling winches, coke cutters, pulsating screens and gas plant conveyors: Strachan & Henshaw Ltd.
Silo air-conditioning plant: Silica Gel Ltd.
Flow integrators: Tecalemit Ltd.

Inhibiting corrosion of hot water tanks

Failure of domestic hot water tanks after a short time in service is a serious problem. The Canadian National Research Council was asked to survey the situation and, if possible, to make recommendations. The survey included 5,200 tanks of all ages up to nine years old and, during the first six months of the survey, 300 of these tanks failed because of corrosion.

An examination was made of 55 of the corroded tanks collected from 15 different localities in Ontario, by members of N.R.C.'s divisions of building research and applied chemistry. Analyses included photomicrographs of zinc coatings on steel tanks that had failed in service.

So far as corrosion of galvanised steel tanks is concerned, large heaters (3 kW.) operated intermittently by hand are better than small heaters (500 W.) automatically controlled because with the large capacity heaters it is not necessary to store hot water in the tank during the night. From this point of view, the thermostat should be used only as a safety device. In any event, a number of the thermostats encountered were quite inaccurate. The most practical method of improving the service life of galvanised tanks is thought to be by adding corrosion inhibitors to the water just before it enters the tanks. Simple devices for doing this are available and tests are now going on concerning the kind and amount of corrosion inhibitor to be recommended.

Chemical Industry Expansion and Plant Supplies

By Dr. W. D. Scott

(Deputy Managing Director, Monsanto Chemicals Ltd.)

The prosperity of the British chemical plant industry hinges directly upon the ability of the chemical industry to expand. This was the basic theme of the speech by Dr. Scott at the recent annual luncheon in London of the British Chemical Plant Manufacturers' Association in which he suggested ways in which the chemical industry and its plant suppliers might improve their collaboration to overcome common problems and to ensure the continuing growth of chemical manufacture in Great Britain. Exports, standardisation of chemical plant, chemical engineering research and the conservation of scarce constructional materials are among the topics dealt with by Dr. Scott.

LET us first look at the record of the British chemical industry. The value of capital assets directly associated with chemical activity is difficult to determine, but it cannot be less than £500,000,000. The 1951 capital expenditure by the chemical and allied industries has recently been quoted as £56,000,000, which means that we are absorbing 12-15% of the total new capital now being created by manufacturing enterprises. This could be regarded as encouraging, for the corresponding figure for the U.S.A. is 8-9%. But remember that in the chemical industry we have a long way to catch up.

It does not need Government admonition to tell us that the nation's rate of capital expenditure is too great for the country to afford at the present time. The facts and figures speak for themselves. Figures for the last four years reveal that whereas from 1948-1950 we were financing capital formation, exclusive of Government capital expenditure, to the extent of 60-75% from profits and reserves, the figure for 1951 is only 24%. The difference is to be found in tax reserves. The corresponding figure from the U.S.A. in the rapidly expanding chemical industry hit by the incidence of excess profits taxes, will be nearer 60%. But in the U.S., in order to encourage the private enterprise system, they have the system of certificates of necessity with accompanying alleviation of depreciation rates. This has benefited both industry and the defence programme. Many of us must wonder why it has not been under study here. Instead we have an excess profits levy which would seem to be aimed at those contributing most to national recovery and may well not effect the exploiting opportunist who works with low capital and plays little part in building up national assets.

Economic and political policy

So we go on complaining. Controls, allocations, frustrations, lack of incentives seem to have become a very part of our thinking. Habits soon become a way of life and we are already expecting far too great a measure of dictation and advice from Government, whether it be from the politicians or from the permanent officials. So the first matter on which I would like you to ponder is the desirability and necessity of industry playing its full part both in the formation and the implementation of national policy.

Sound policy needs good communication. National policy is made by and for the advantage of the people. So the vote of the people will always be the prime concern of the politicians and we must pray that this should always be so. If we appreciate this fact I am sure it will give us a better understanding of the actions of the politicians. Many an industrialist naively believes that communications will automatically flow both to his people, who are the voters, and to Government, providing his balance sheet and profit and loss account look sound. So before we criticise both Government and political actions and beliefs I would suggest that we question ourselves whether we have done all we can to influence those who determine the nature of Government. Are we industrially doing all we can do in our political and human relations ?

To help to formulate policy we have got to understand our problems and be able to communicate our thoughts. Do we know what we want ? Do we know why we do not get what we want ?

The chemical industry

Let us briefly take a look at this chemical industry with which we are all so very much concerned. It is a difficult and abstruse industry to the non-technical man. To the uninitiated it must be difficult to grasp the tremendous latent potentials of our industry. It will therefore do no harm to review our claims for priority in utilising the limited capital resources which are available to the nation at the present time.

C.I.C. instructions

You will remember that the Chancellor of the Exchequer's instruction to the Capital Issues Committee gave the following order of priority:

(1) Essentially and positively related to the rearmament programme.
(2) Stimulation of exports to desirable markets.
(3) Savings of imports and the relief of basic deficiencies especially of raw materials.
(4) Technical development of industrial production and the more efficient and economical use of resources.

If you reflect on these priorities in terms of building up the national assets it will probably occur to you that they might well have been stated in the reverse order. Unfortunately, because of the sins of omission of the past, we are continually having to fall back on opportunist policies. So few today would argue against the necessity of the short-term view to deal with the political and economic catastrophes which could confront us. Suppose we take a look at these priorities and start pondering on their importance to us as an industry.

Defence

As an industry we do not manufacture aircraft, tanks, radar equipment or missiles, so our claims for the super priority recently announced are small. However, many of our products are required as raw materials for the manufacture of these positive defence items, while in the manufacture of munitions our industry plays a leading part. Nevertheless, I would like to point out that in 1939 few chemical works in this country found they were manufacturing products which were not required both urgently and in greatly increased quantities. The industry is both basic and resourceful, being by its very nature very adaptable to change. So I would ask our Ministerial friends not to worry because some part of our products end as unessential or luxury items at the present time; if the worst happened, the production facilities would be of tremendous value whereas most of the direct defence requirements, however necessary today, are valueless as long-term national assets.

Exports

Now let us take a brief look at the export claims of the chemical industry. The record is excellent. At the present time the

seriousness of the balance of trade position is demanding a short-term view of exports. We readily accept a policy that all available manufactured goods must be exported even to the detriment of capital projects already in course of construction, but we would join our plea with other industries that if the policy is not changed at the earliest possible opportunity the consequences could be most unfortunate. The chemical plant industry has always played a prominent part in the export drive, but, as stated in your Annual Report, your export achievements must be limited by the prior claims of the home chemical manufacturers whose contribution to the national economy and the defence programme is vital. Your Report goes on to record that the Ministry concerned still accepts as valid the argument that while the chemical plant manufacturers should be encouraged to increase their exports, in view of the claims of the home chemical industry, no target should be set. This is most encouraging and we trust that it is a policy which will be fully implemented to the extent of allocating the appropriate raw materials to your industry.

Importance of time

In connection with exports I would like to emphasise the importance of time. Time costs money in capital and markets. We are able as an industry to compete in world markets with a large number of our products. In terms of world trade we are favourably placed with many basic raw materials. We can work out new processes and we can evaluate economic projects thereon. But again and again, because of the time taken to design, to license, to fabricate and to erect plant, we find world events have overtaken us and the commercial and economic bases of our evaluations are proved to be false. **Is it not a very disturbing thought that we take twice as long as Germans or Americans to complete a project?** Is that the way to take full advantage of our opportunities? Where is the fault? Possibly it lies in part in bad communications, in part in lack of standardisation, in part in lack of appreciation of the size of the project, and in part in too many people asking for a share of the cake. How are we going to resolve these problems? Perhaps we could just look at them one by one.

Industry communications

Firstly, let us examine the communications between our two industries. Time and again we hear the well-justified criticism that the chemical industry is for ever changing its mind. I have already stressed that it is an industry of change. But the plant makers, as the suppliers of our capital goods, are justified in demanding some stability of requirement. So I would plead with our industry to make up their minds and freeze their process design so that the plant design can be expeditiously executed. Having made that self-criticism I must now look at the other side of the picture. Our requirements do change rapidly and unless you can hasten the mechanical design and fabricating processes you are bound to get into trouble with an industry in which the technological advance in a period of three years may be very considerable. So don't let us run round in circles, but let us try to understand each other's problems so that we can help to save time.

Standardisation

The next factor adversely influencing timing would appear to be lack of standardisation. The problem is difficult and the principle of standardisation is not acceptable to everybody. There have been meetings to discuss the problems involved at which platitudes and some wise words have been spoken. As an Association you have actively supported the British Standards Institution and your Annual Report indicates that you are prepared to do more. A part of the chemical industry would certainly like to see a much greater rate of progress and therefore has joined with certain elements of the petroleum industry to determine whether certain of their common interests could not be codified. We could envisage a tremendous saving in design, fabrication and construction time if the process design engineers could pick from the shelf functional items of equipment such as heat exchangers, pumps, enamelled vessels, valves and cocks, filters and centrifuges. In this respect the U.S.A. are far ahead of us and thereby have a very great advantage in time. I would therefore plead with you to proceed with the principle of standardisation as rapidly as possible, and I can assure you that important sections of the chemical industry will be with you.

Research

The view has been expressed that standardisation could react against the smaller companies and militate against creative developments. Naturally the chemical industry would hope that standardisation would lead to lower costs and therefore to lower prices. It could also lead to greater margins to be ploughed back into creative techniques of fabrication. As an industry we would strongly urge you to become big enough to afford research. So we are delighted to read in your Annual Report that the conclusions of the Cremer Committee will be fully considered by your Council. But please remember that your problems cannot be entirely solved by a central chemical engineering research organisation. It is the use you make of new information communicated to you that matters. Opportunities for experimentation abound in the chemical industry despite our insistence on standardisation and, if we get standardisation where it is due, there is much more scope for the experimental approach. For the moment we ask you to do everything you can to save time. For the future we ask you to appreciate the great opportunities which await you. Maybe they can only be exploited by a greater degree of co-ordination among yourselves and with the chemical industry than exists at present.

Limited resources

I am on more difficult ground when talking of a share of the cake. Time has been lost because too many tasks have been undertaken. There has been too great a demand on limited resources. Whether pooling of effort would extend those resources I do not know. But the problem exists. If you have lost time because of lack of materials we can suggest to the Government Department responsible that either there has been lack of recognition of the importance of our industry or your allocations are inadequate. In our demands on your facilities and products we compete with a powerful and all-consuming industry, but in terms of capital expenditure and product value we are still the more important. But perhaps we haven't told anybody yet.

Technical competence

My arguments for putting our joint houses in order to improve our export position have not unnaturally led me to the fourth priority instruction of the C.I.C. We cannot expect to export unless we are technically ahead of our competitors and are making a more efficient and economical use of resources. Indeed this factor is also, as far as the chemical industry is concerned, very much intermeshed with the third priority instruction, namely, saving of imports and reliefs of basic deficiencies. With our present population level we have many basic deficiencies, not the least of which is food. Our wise husbandry in years gone by has influenced the farming products of the world. Are we today as an industry and as a nation putting as much technical effort as we should into the productivity and fertility of our soil?

Commodity and mineral replacements

Most of the commodities we utilise in manufacture are also imported and here we are faced with startling developments. Many basic commodities which affect this country's trading future are threatened by chemical developments which seemed to be merely of academic interest 15 years ago. We are confronted with commodity replacements in every direction and in our fight to preserve the commodity front we may well be losing our commercial position to the U.S.A. The position of natural rubber is already precarious. The price structure of wool is threatened by synthetic substitutes. Many substitute plastic materials now exist for natural hides and skins. Plastic tubing has replaced copper. Vegetable oils are not the dollar earners that they were. I do not suggest that it

would be a wise policy for us to spend capital blindly on projects for these substitute materials at the present time. If we did we would just be putting out of business our own kith and kin and at the same time we would lose some very valuable export markets. Nevertheless, sentiment for past commercial traditions must not be allowed to block natural economic trends. It would seem wise therefore for every incentive to be given to the chemical industry to keep the nation, in a timely way, in the front of technological developments.

Stainless steel

The world shortage of certain minerals is also of the utmost importance to us. It is appropriate here to make reference to the development and utilisation of stainless steel within the chemical industry. Your Association has, as stated in your Annual Report, taken every opportunity to make it clear to the Ministry that stainless steel is essential to the manufacture of a wide range of chemical plant. By the use and development of this material the chemical industry has already saved many thousands of tons of both steel and that new rare metal—lead. It is, I suggest, just foolish to believe that the chemical industry can do without alloy steel, though it is equally foolish for the chemical industry to press its demands solely for the sake of a gold-plated job which will last for ever. On the other hand, I know of one plant which is in a state of dissolution as a result of foolishly submitting to pressure to use steel of unsuitable properties. Your Association has done a grand job in securing co-operation with chemical manufacturers in modifying specifications involving alloys of steel in cases where alternate materials are adequate for the duty involved. We are confident that the Ministry concerned is appreciative of these efforts and would have no intention of holding us up by actions which would only serve the purpose of destroying our world competitive position.

Automatic control

Finally I would like to refer to efficiency in use of labour resources. Recent figures have demonstrated the high capital investment per unit of labour in the chemical industry. But judged by the performance of the petroleum industry to which we are a bad second, there is much room for improvement. By the very nature of many of our processes it is possible and desirable to eliminate manual operation. The chemical process is a communication of information in such a form that control is readily applied. Automatic control as practised by the petroleum industry and the distant control of nuclear reactions have advanced to an extent just unbelievable by many. We are beginning a second industrial revolution in which the mechanical mental reactions of men will be usurped and in which even the reasoning of the brain of man may even be partially replaced. The science has been christened cybernetics and its consequences may have a deeper significance than I can dwell on at the present time. The concept could certainly be of great importance to this country and the chemical and chemical plant industry, if given the incentives, can undertake some valuable pioneering in the technological and sociological aspects of the science of communication.

Associations

So I would like to finish on the topic on which I started, namely, the importance of communication in forming and implementing policy. It is associations such as your own and our own which through their lateral lines of communication with their members and related associations can help to bring to the notice of the nation the importance of our industries to the national welfare. So I urge you to meet each other more, exchange views more freely, to become a platform for your industry, to become recognised as a representative association, whose views will always command respect, and then you will have played your part in determining and implementing policy.

New Fatty Acid Distillation Unit

A NEW continuous fatty acid distillation unit has been devised to yield a product which is light in colour and otherwise in conformity with established standards. It is intended as an improvement on present units which do not usually remove light ends or achieve the colour-stable product required for the manufacture of plastics, candles or toilet soaps.

In *Chemical Engineering*, F. B. White of the Foster Wheeler Corporation states that the principal feature of the new unit is a continuous still. This consists of a horizontal shell with two *Dowtherm* heated reboiler bundles inserted at opposite ends. Half-way between them is a vertical separating wall, welded to the shell but open at the bottom to permit the passage of liquid from one zone to the other. Crude fatty acids containing moisture are fed into the smaller section, where they are preheated and dehydrated by vapours being distilled in this zone. This practically eliminates fouling of the reboiler heat transfer surface. In the dehydration zone, a small percentage of crude fatty acid is distilled overhead with outgoing steam. This light boiling fraction of the feed stock, which may contain a relatively high concentration of unsaponified material as well as colour bodies is collected separately for redistillation, thus ensuring a lighter, more colour-stable product.

Dehydrated stabilised fatty acids pass under the central baffle into the second distillation section, where they are separated from the residue in a bulk overhead distillation. Carry-over of residue is kept to a minimum by means of centrifugal separation and mechanical eliminators.

Tempered water in the fatty acid condenser is used for handling high-titre distillates. Water temperature control is automatic.

The vapour passages are very large, so that the use of high vacuum and stripping steam ensures a very low distillation temperature. It will be possible, with this new unit, to handle unstable unsaturated stocks. Also, operation of the system is continuous with little hold-up of liquid in the unit, so heat-sensitive feeds may be used. *Dowtherm* was employed as the heating medium because of the cost, though condensing steam would be equally satisfactory from a process point of view. To obtain a heating-medium (not distilling) temperature of 486° F., steam at 615 lb. gauge pressure would be required, whereas *Dowtherm* at 5.2 lb. pressure condenses at 520° F. Steam at pressure as low as 450 lb. could be used, but would have other disadvantages.

Circulating liquid would not be satisfactory as a heat medium because it would destroy the advantages accruing from low temperature heating surfaces and would require the use of expensive pumps.

All entrainment is first removed in a centrifugal separator. Afterwards, a second separation is effected with a mechanical mist eliminator, which is most efficient when handling vapour containing a very small percentage of liquid.

Capital costs of this unit are low, because of the compact nature of the alloy still resulting in low equipment charges. The same compactness has an even greater effect upon erection costs, all piping being eliminated between the two stages of distillation. No piping is necessary either between the first distillation zone and its partial condenser. The whole unit, therefore, entails a small distillation structure and low auxiliary costs.

'C.P.E.' — June

Articles next month will include :

Chemical Engineering Progress in the Gas Industry, Part 2, Storage, Utilisation and By-Products.

Simplification in Stainless Steel Specifications.

Treatment of Waste Waters from Penicillin Manufacture.

Chemical Engineering at the Cross-Roads.

Graphite evaporator

We regret that in giving the performance figure of the new Powell Duffryn evaporator which is built of graphite (March issue, p. 128) a nought was inadvertently omitted. The unit can evaporate 1,300 lb./hr. of water, using steam at 75 p.s.i. We apologise to the company for this mistake.

New Factory for Making Fine Chemicals in Bulk

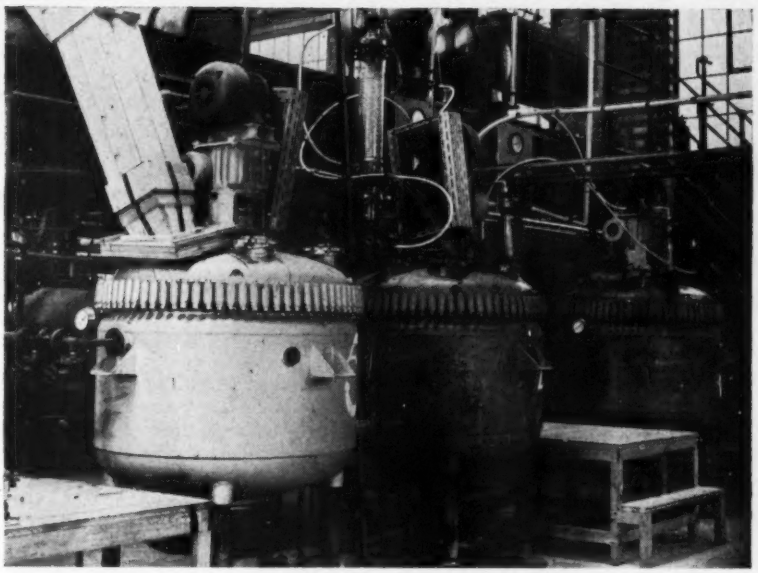
Along the bank of the Humber in North Lincolnshire are the beginnings of what may one day be an important new centre of chemical industry. Already there are big factories for manufacturing fertilisers and titanium pigments. Now the chemical picture is still more diversified by the starting up by Ciba Laboratories Ltd. of a factory for the manufacture of pharmaceutical chemicals in bulk.

HITHERTO Ciba Laboratories Ltd., the British subsidiary of the well-known Swiss chemical company, Ciba Ltd., Basle, has produced certain chemicals on a small scale at its Horsham, Sussex, factory. However, this factory was designed for pharmaceutical processing, and such chemical manufacture as has been carried on has been largely improvised. To provide facilities for the manufacture of all Ciba's pharmaceutical chemicals in bulk a new site was needed. This has been found at Pyewipe, Grimsby, which is an industrial estate on the banks of the Humber. With an eye to future expansions and in fields other than pharmaceutical and fine chemical, Ciba have acquired a site of 100 acres which reaches to the river. The site has two features of first importance to chemical manufacture: a supply of water (the factory has its own borehole with a pumping capacity of 30,000 gal./hr.) and a waterway into which effluent can be piped.

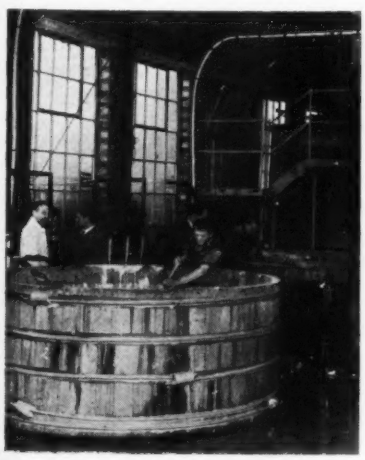
So far 10 acres of the site have been developed. The buildings are steel-framed and brick-panelled and house offices, laboratories, chemical plants, boilers, refrigerating plants, effluent treatment units, etc. At present the only plant working is designed for the manufacture of *Cibazol*, Ciba's well-known brand of sulphathiazole, of which they were one of the two originators.

Plant procurement

A good deal of improvisation has been necessary to get this plant erected and working. It is not easy to get new plant quickly, and many units, such as storage tanks and vessels, cast-iron and rubber-lined reaction vessels, have been bought second-hand and adapted for the new job. Some of the items have come from redundant Ordnance factories, others from military installations; there are even items of German reparations equipment, mainly 2,000-litre stoneware storage vessels. Steel platform plates from the dismantled Mulberry Harbour have proved readily adaptable as stagings for chemical plant. Wide use has been made of wooden vats for various processes, *e.g.* vacuum filtration. Exhaust ducts over certain vessels are of wood also.



Glass-lined kettles, part of the general purpose equipment used for the manufacture of 2-amino thiazole.



The acid chloride plant showing the wooden vacuum filters in the foreground and the glass valves and 'Alkathene' pipe runs behind.

Plastic and glass

One interesting feature is the very extensive use made of *Alkathene* piping. This polythene plastic has proved easy to weld and fit, and in every way admirable for handling chemicals. It is certainly an eminently sensible way of utilising this material and one which should be more widely adopted. Another modern chemical engineering material which is encountered frequently in this plant is glass. Glass pipes combined with polythene and glass valves are seen everywhere. Besides its other virtues, glass has the advantage of making visible the chemicals being handled. Thus, continuous observation of different parts of the process is possible. One unit, a hydrochloric acid absorption tower, is made completely in glass. It is similar to one shown in the Dome of Discovery at the recent South Bank Exhibition of the Festival of Britain.

In designing the factory, the aim has been, apart from the *Cibazol* plant, to provide general-purpose equipment capable of manufacturing a very wide range of chemicals.

The sulphathiazole plant

The first stage in the manufacture of *Cibazol* is a chlorination. This is carried out in a large flameproof building which also houses the units for the fractional distillation of the chlorinated product. To save on expensive flameproof switchgear, provision has been made to accommodate ordinary switchgear *outside* the main building. A simple solution to the problem of preventing inflammable vapours entering these switchgear annexes through ducts has been to run all cables first out of the main building and then into the annexes.

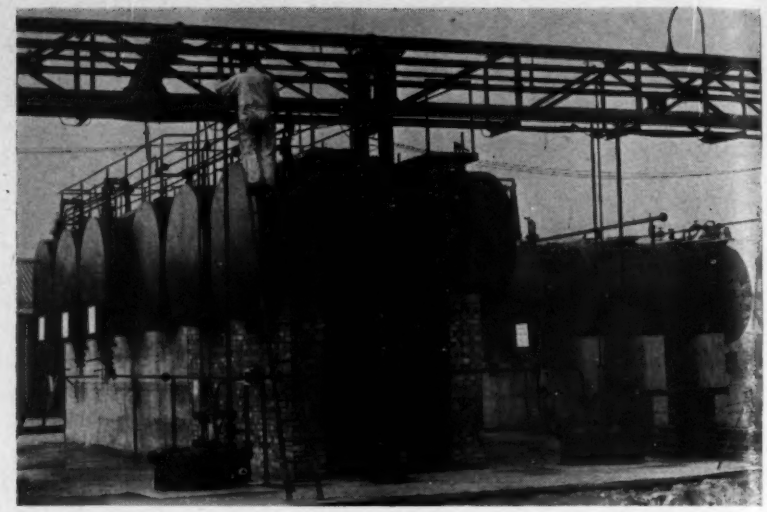
For cooling purposes in the chlorination stage there is a *Freon* refrigerating unit for cooling 30% methanol for circulation through the jackets.

Purification is carried out in an adjoining building. This houses a multi-purpose

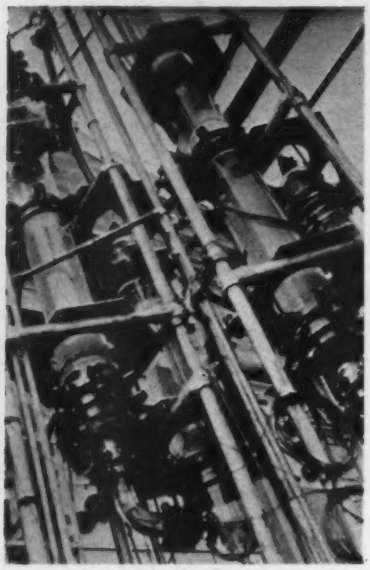
unit capable of performing various methods of filtration. One part is used for acid filtrations, the other for alkaline liquids.

Next to the purification plant is the boiler house. Here are two Lancashire boilers with economisers and superheaters. The capacity of each boiler is 10,000 lb./hr. of superheated steam.

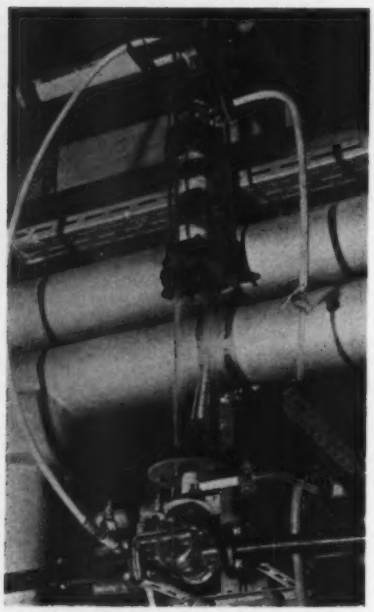
Between the block of buildings described and that in which the final stages of *Cibazol* manufacture are carried out is a tank farm for storing acids, caustic soda, etc. For chlorsulphonic acid storage there are six 25-ton tanks.



Main tank farm: acid tanks on the right, caustic tanks on left with blowing egg in the foreground. Above is the main service pipe bridge.



The glass HCl absorption equipment. The coils at the right-hand bottom corner are thermometer capillaries.



A good illustration of the use of plastic and glass. This apparatus allows samples of a chlorinated product to be withdrawn for specific gravity measurement without coming into contact with damp air.

Next comes a refrigeration plant which services the acid chloride stage of manufacture. To facilitate the distribution of ice to the various vessels where it is needed, the actual refrigerating unit is elevated well above the level of the processing vessels, thus permitting gravity feed. In the final stages, reactions are carried out in vessels equipped with stirrers. As already mentioned, vacuum filtration is performed in large wooden vats. Finally, the product is dried in hot-water heated ovens.

Other products

As soon as *Cibazol* manufacture is under way, the balance of the plant for other products will be completed. Chemicals scheduled for early attention include *Coramine* (pyridine-β-carboxylic acid diethylamide), the cardiac stimulant, *Antistin*, the imidazoline anti-histaminic, and *Vioform* (5-chloro-7-iodo-8-hydroxyquinoline), the antiseptic. All these fine chemicals will be sent to Horsham for pharmaceutical processing, whence many will be exported. This is particularly the case with *Cibazol*, and the new plant is expected to save dollars in the overseas purchases of drugs.

As the factory is still very much in the constructional stage, there is a good-sized engineering staff and a large workshop. In all there may be 150 people employed, and the processing units are worked on a three-shift basis, 11 days a fortnight.

Technical development

In addition to the processing and other facilities described there is a technical development section in the course of being equipped. This is designed for the study and improvement of manufacturing methods. In this section most organic manufacturing processes and operations can be carried out with batches ranging from 100 cu.cm. to 200 l. In this section particularly advantage is taken of flexibility in design made possible by glass pipe and glass equipment for constructing pilot plants.

The manager of the factory is Mr. J. G. Bedford, who, with his chief engineer, Mr. J. S. Palmer, and the advice and assistance of Swiss engineers under Dr. F. Locher, was responsible for the design, layout and installation of the plant.

Principal suppliers of plant and equipment

Glass-lined equipment: Cannon Iron Foundries Ltd.; Enamelled Metal Products Ltd.
Glass stills and recovery columns: Quickfit & Quartz Ltd.
Glass piping: James A. Jobling & Co. Ltd.; Quickfit & Quartz Ltd.
Hydro extractors: Thos. Broadbent & Sons Ltd.
Cast-iron vessels: Brown Foundries Co. Ltd.
'Alkathene' piping: Chemical Pipe & Vessel Co. Ltd.
Rubber linings, piping and pumps: Dexine Rubber & Ebonite Ltd.
Steel piping: Foster Bros. Ltd.; Le Bas Tube Co.
Timber vats and laboratory furniture: Cygnet Joinery Ltd.
Valves and fittings: Bell's Asbestos & Engineering Co. Ltd.; Saunders Valve Co. Ltd.; Audley Engineering Co. Ltd.

Recent publications

Liquid control systems. A booklet describing their liquid control systems with bulk storage, pipe line dispensing to points of use and accurate metering of dustrial liquids is available from Messrs. Liquids Control. Storage tanks of mild steel, aluminium and stainless steel, etc, can be supplied. Rotary gear, centrifugal, reciprocating and hand-operated pumps are also available, as are meters for delivering pre-determined quantities of liquids.

Vacuum separator. Specially designed for separating oversize particles from a previously ground aggregate, vacuum separating plant built in 3 ft., 4 ft. 6 in., 6 ft. and 7 ft. diameters are described in a new leaflet from International Combustion Ltd. The separator has three applications. It can be combined with a pulveriser to form a closed-circuit system, it can be a self-contained unit, or it can be used as an auxiliary to grinders without air separation as an integral part.

Extraction and Utilisation of Methane from Collieries

By D. W. Gillings, Ph.D., F.Inst.P., A.R.I.C.

(Central Research Establishment, National Coal Board)

The extraction of methane or firedamp from coal mines is both an important safety measure and a means of obtaining a valuable raw material suitable for use as a fuel or as a basic chemical. The following article* describes British developments in extracting and utilising methane and it is thus complementary to the article by R. J. S. Jennings appearing elsewhere in this issue.

METHANE has been found with coal ever since deep mining began and the danger of explosion, arising from its emission into airways and workings has long been recognised. Since the safety lamp was invented 150 years ago, the standard method of obviating explosion risks was, until very recently, the isolation of any possible source of ignition from a source of methane.

During the last few years, however, there have been developments with an essentially different approach in which firedamp is tapped from nearer its source in the coal measures by drilling directly from the mine roadways and setting up a pipeline system or range through which the gas can be extracted and taken to the surface independently of the normal ventilation air of the colliery. Some of the advantages of such a scheme will be immediately apparent, particularly the actual reduction of methane released into the mine as a potential danger. A second and very different benefit is obtained by removing the methane directly without dilution. The gas is then available for use as a fuel or as a basic material for chemical synthesis. The second aspect of the development will be of most interest to chemical engineers.

Methane is encountered in most coal mining operations today and is particularly troublesome when an entirely fresh coal face is being developed.

Escape of methane from coal workings

While it would be quite incorrect to suggest that the various modes of evolution of methane from coal seams and the way in which gas accumulates in colliery workings could be grouped into any general pattern, most of the installations of firedamp drainage methods have been applied to those long wall workings in which fairly characteristic pattern of accumulation of gas takes place. It is commonly found that the release of methane as firedamp at the coal face is comparatively small and it is not uncommon for only 0.5% of methane to be discharged into the air by the time the ventilation current has reached the return air-way. At this point, however, it is a common observation in gassy mines that the percentage of gas builds up rapidly as the distance from the coal face increases along the return air-way and there are some instances in which the percentage of methane has risen to over 2% within 100 or so yards of the coal. It is known, in general, that gas is discharging from coal which has not yet been cut as the return air-way advances through the seam, and also from the wastes, or region from which coal has been extracted and into which supports for the roof have been built by one or the other of the standard methods. Firedamp is often released in large quantities from the first seam in a colliery, and trouble also arises from restricted regions of colliery workings and wherever there is a geological fault. Efforts to withdraw methane by pipework, without it discharging into the main airways have been made for many years, but extensive development of firedamp drainage methods dates from the early 1940s.

At Mansfeld Colliery in the Ruhr, a borehole, which was being drilled to extend a vertical shaft, began to deliver a great volume of gas. This was lined and utilised for the removal of gas, although it had not primarily been drilled for the purpose. The advantages of this system of removal were recognised and it was extensively developed. Very soon the colliery boilers were fired with methane, and shortly afterwards equipment was installed to convert it into a substitute for petrol. The system was later extended to mines in Belgium and the Saar. From it two main additional techniques of mining have been evolved which meet most of the requirements for firedamp drainage. It is of fundamental interest that although the first bore holes in the first typical installation at Mansfeld were used only incidentally for firedamp drainage, the operation was carried out as a part of workings involving two or more adjacent seams of coal. This has been found to be essential in most examples of practice so far encountered.

In the present accepted schemes for the successful drainage of firedamp from an advancing long wall face, bore holes are driven vertically in the roof of the return air-ways commencing at the coal face and thereafter at 10 yd. intervals or thereabouts, all back along the return air-ways. A continuous programme of boring is maintained so that each time the face advances by 10 yds., that is in about 10 days working, a further bore hole is drilled into the roof, and common connection made to a pipe range which is extended as the face advances. The pipe range for each face may connect to a main extraction range in a colliery where many faces are subjected to direct drainage, as it was found by early experience in the German operations that the rate of gas flow can be greatly increased by application of the suction of about 1 to 2 lb. per sq. in. to the bore holes. There are many detailed variations in working on this general principle, but a few points will characterise the results usually obtained by the method.

1. Gas is generally present at pressure of a few inches water gauge and in quantity up to 100 cu. ft. per min. per bore hole.

2. The maximum flow of gas is generally reached when the face is 50 to 100 yds. away from the bore hole and the flow frequently reduces over the months of subsequent advance of the face and increase of distance from any one bore hole. During this period, of course, fresh bore holes come into operation.

3. The flow of gas is dependent on the continuity of mine operations. If for any reason the face should be stopped, the output of gas falls gradually.

4. If the ground is moved by adjacent mining operations in other faces, or elsewhere, the output of gas may be much greater than when the one face is being worked steadily and alone.

In most installations, some measurement has been made of the individual flow of gas from each bore hole, standard fittings and mountings, and orifice plates and pressure tappings being provided in some installations. A limited number of experiments has been carried out to determine the best direction depth and diameter of bore holes, and while there is so far no answer applicable to every case, it is frequently found that output of gas is increased when the bore holes are not vertically upwards but are inclined over the waste, that is pointing to the centre of the coal face and, in some

*An abridged version of a paper read before the Chemical Engineering Group and the Nottingham Section of the Society of Chemical Industry at Nottingham on February 7, 1952. The paper was presented with the permission of the Director-General, Scientific Department, National Coal Board.

cases, pointing forward to the direction of advance of the coal face also.

Another method has been used quite extensively, particularly in the Saar coalfield. This practice can be applied only where coal seams are fairly close above each other. A heading is driven in a seam immediately above a worked seam and the entrances to the heading are sealed with a concrete dam. It is then found particularly when the ground is being extensively worked around this heading, that firedamp collects in it and can be extracted by a pipe-range. There is one important difference, however, the methane drawn from individual bore holes is generally fairly pure with methane contents frequently upwards of 90%, while the gas drawn from the headings is often about 50% air.

Firedamp drainage in British mines

A number of new installations have now commenced operation in this country, all of them using the system of individual bore holes driven in the roof of return airways of long wall workings.

There is a much greater emphasis on the experimental approach to these operations in British mines.

For many years prior to this, however, operations have been carried out which were, and still are, without parallel in the records of coal mining throughout the world. At Point of Ayr Colliery, in North Wales on the estuary of the Dee, bore holes have been drilled into the virgin coal seams from the seams already worked and almost pure methane flows readily from these holes under its own pressure. This direct boring into the coal measures before working has been a standard feature of mining practice at Point of Ayr for 60 years and is continued today with full appreciation of its importance. An unusual feature of the gas emission at this colliery is the high pressure at which the gas is held in the coal seams.

The technique of operation

The technique of firedamp drainage is basically straight-forward. The correct form of drill must be used which is usually a rotary compressed air drill with hard metal tip, the drilling being carried out with a very high thrust to ensure rapid penetration and a quick completion of the bore hole. A stand pipe is grouted into the hole at an early stage in the operations and a stop valve fitted. A pipe layout is then connected to the bore hole and boring is continued through the main valve until coal bearing measures are encountered or until the output of gas from the hole reaches the maximum. The gas output is led to a main through the flowmeters. In an installation of any size and permanence the suction is applied from plant on the surface to the gas mains leaving the shaft. When properly applied there can be no doubt that firedamp drainage improves the safety of the mining operations. It is, of course, an important part of an operating technique to maintain the regular provision of bore holes as the working face advances, and there is much to be said for the exclusive use of one drill for the extension of the bore hole system.

Methods of utilisation

The measurements carried out so far in British and Continental collieries indicate that a reliable yield of methane can be obtained from about four or five active bore holes of a series at any one coal face. On a basis of about 50 to 80 cu. ft./min. per bore hole, this suggests that a representative colliery working two or three gassy faces might deliver between 600 and 1,000 cu. ft./min. of methane to a collection range and this volume amounts to 1,000,000 to 1,500,000 cu. ft. of methane or 20 tons daily. This order of yield is sufficient to demand serious consideration for a number of chemical processes of utilisation as well as use as a fuel.

The uses can be grouped into those where the methane is primarily required as a fuel and those where the final product is primarily required for its chemical properties. The fuel uses are:—

(*a*) Direct replacement of coal in boilers, generally on colliery sites.
(*b*) For admission directly to industrial gas networks without intermediate processes.
(*c*) For heating coke ovens to release equivalent fuel value of coke oven gas.
(*d*) For conversion by cracking to a gas of correct calorific value and density to mix with town or industrial gas.
(*e*) Compressed or as a liquid for use on vehicles.

The main chemical uses are as follows:

(*a*) Conversion to acetylene by a number of processes.
(*b*) Chlorination to methyl chloride, and solvents.
(*c*) Reforming for synthesis gas.

Use of methane as a fuel

Methane can be regarded as a high grade fuel, being a clean gas of high calorific value, but even so, its value is less as fuel when subjected to relatively extensive chemical changes to exploit its potential as a raw material.

At present the gas is used only as fuel at firedamp drainage sites and no installations have yet been completed for manufacture of chemical products.

Firing of boilers

This was the earliest use of the gas and it will probably continue to be extensively applied as the first stage of exploiting the output from new firedamp drainage installations. At Hirschbach Colliery, Saarbrucken, one of 6 water tube boilers has been converted to burn gas. No special plant is required and the burners are a straightforward air injector type. The flow of gas, make of steam, and efficiency of combustion are adequately measured and recorded by usual boiler house instruments and the installation runs with high efficiency. Under favourable test conditions about 10,000 lb. of steam per hr. has been raised with nearly 90% efficiency, and over 80% efficiency is regularly maintained.

Delivery of methane to industrial gas grids

It is at present contemplated that this shall be the major use of the gas at Continental installations, particularly those at the Belgian mines. Gas grids for distribution primarily of coke oven gas have been established in the Ruhr and in Belgium, where the demand for gas directed attention to auxiliary sources. It is expected that about 10% of the peak demand in Belgium can be supplied by methane from drainage, and pipelines have recently been laid to connect selected collieries, ultimately about 20 or more to the distribution system.

Methane has a calorific value of nearly 1,000 B.Th.U./cu. ft. while coke oven and gas works gas has a lower value around 500 B.Th.U./cu. ft. It is thus not possible to supply the methane in unlimited amounts without further processing, and this can be done in three main ways. The gas can be simply diluted either with air or preferably with producer gas, or it can be used to heat coke ovens and release coke oven gas, or it can be reformed by catalysed cracking to give a mixed gas of lower calorific value.

Methane as a fuel for I.C. engines

The original utilisation of methane for firing boilers at Mansfeld Colliery was soon superseded by a high pressure gas compressing set, and bottling the gas at 2-300 atmospheres in containers carried on motor vehicles to replace petrol. This was of highest importance to the German war economy at the time, but this method of using methane has not been widely extended and certainly not to the exclusion of other uses. Another similar installation is operating near Saarbrucken, and the possible use of methane in this way has been extensively considered in this country.

The combustion characteristics of methane make it a satisfactory fuel as such for internal combustion engines, but it has certain disadvantages. It has been suggested that the gas could be more readily stored on railway vehicles, and its use as fuel in internal combustion locomotives has interesting possibilities.

Its properties as an engine fuel can be more readily exploited in stationary equipment, and the steam boiler and turbine plant at Point of Ayr Colliery will be replaced as plant becomes available with high compression dual fuel engines of much greater efficiency.

However, the real value of methane at the present time lies very largely in the ease and cheapness with which it can augment other available natural resources

with the minimum of delay. At collieries the boiler fuel released can today, whatever its quality, be used in other plant which is short of fuel. Coke oven gas now may be more valuable than methane used with different fuel equipment at a later date. Engines of standard design are in production now which can run with full efficiency as soon as they are installed.

Methane as a basic chemical

When turning to the use of methane in chemical processes it must be remembered at the outset that it is not by its very nature a material of widespread application unless substantially altered at early stages of chemical reaction. It is the lowest member of the paraffin series, and is as comparatively inert as the name of that series implies. Practical experience extending over many years bears out the importance of this peculiar chemical inactivity. Methane has been available for years now from gas separation plants at some Continental coke ovens, from sewage treatment plants and as natural gas from oilfields, but only in the last instance has any great chemical industry developed around such supplies. This is, however, only an indication of relative trends on the exploitation of numbers of possible chemical fields and the time may well have arrived to expect more intensive developments. The actual processes in which methane assumes importance as a raw material can be dealt with broadly as those leading to acetylene as a first stage, the processes for direct chlorination, and the extensions of the reforming process to the production of synthesis gas for reconversion by the Fischer-Tropsch process.

Acetylene synthesis is carred out in a number of ways, including arc cracking, partial combustion and regenerative cracking, differing considerably in detail and operation, all but one having the common feature of subjecting methane to a high temperature, in excess of 1500° C. for a very short reaction period, followed by very rapid cooling to stabilise the equilibrium so attained.

Several processes have been operated to obtain chlorinated methanes directly from gas and there are several methods also developed for converting methane to carbon monoxide and hydrogen mixtures.

Enough has been said of the use of methane for chemical manufacture to indicate the widespread potential use. It should, however, be remembered that many of the processes described as technically successful depend on the availability of large tonnages of methane. Since the output for most pits is restricted it might become essential to group a number of pits for firedamp drainage operations. By this means the increased realisation for the gas can be most readily assured, and it is probably to such grouping of pits as this that the industry will look for provision of large tonnages of methane for other than purely fuel applications.

The Motion of Solid Particles in a Hydraulic Cyclone*

By D. F. Kelsall

DURING recent years the hydraulic cyclone has found increasing application in the treatment of slurries and suspensions. Perhaps the most important and best known is its use as a heavy medium concentrator for separating fine coal from shale.

This type of cyclone is also used in the coal-cleaning and other industries for thickening, dewatering, desliming and classification operations.

A fairly close analogy can be drawn between the hydraulic cyclone and the conventional dust extraction cyclone in that both types generally utilise similarly shaped bodies having cylindrical and conical portions, tangential feed to the cylindrical section, centrally placed overflow orifices or vortex finders, and underflow openings at the bottom of the conical portions.

Experimental work so far reported in the literature has been confined mainly to *ad hoc* work involving, for example, examination of particle size distribution in the feed before introduction into a cyclone and in the underflow and overflow after passage. Other work has involved a study of pressure drop and liquid volume flows.

In the work to be described, the movement of fine aluminium particles (mainly less than 50 microns) suspended in water has been studied using an optical method.

The apparatus consisted of a *perspex* cyclone with a 3-in. diameter cylindrical section and a conical portion having a 20° angle, mounted with its axis vertical.

Velocity components

Using suitable ultramicroscope illumination and a microscope fitted with objectives mounted in a disc rotated by a small electric motor, the horizontal (or tangential) velocity components of the particles were measured at selected positions within the cyclone. Vertical velocity components at the same positions were obtained by measuring the angle of inclination of particle paths to the horizontal.

The apparatus was calibrated by rotating cylinders, mounted co-axial in the water-filled cyclone, at various speeds.

Three series of experiments were carried out in which the horizontal velocity components and track angles of particles were measured at selected points on several horizontal levels above and below the bottom of the vortex finder. Each series included experiments made at 10, 20 and 30 and 40 p.s.i. indicated feed pressure.

In the first series conditions were selected such that the volume of the underflow discharge was negligible compared with the overflow. Graphical interpretation of the results indicated that observed velocities of the particles were a measure of the water velocities within $\pm$ 5%.

In the second series the relative sizes of the overflow and underflow orifices were such that no measurable overflow resulted. Graphical interpretation again indicated that the solid particles attained water velocities.

Series 3 was carried out with the cyclone variables set to give both overflow and underflow.

From the inference that the aluminium particles were moving at the same velocities as the water and from continuity considerations, it was possible to calculate radial velocity components for the water.

Main results

The main results may be summarised as follows:

(1) The flow pattern is independent of volume throughput within the range investigated.

(2) A simple relationship of the form V and p^n exists between the horizontal velocity component at a given radius and indicated feed pressure (or total volume throughput).

(3) Except for positions close to the wall the *loci* of positions of constant horizontal velocity components are cylinders co-axial with the cyclone.

(4) The horizontal velocity increases linearly from the wall of the air column to a maximum at a position close to it and then decreases towards the wall of the cyclone according to the relationship Vr^n constant where n has a value in the range 0.75 to 0,85.

(5) Within the accuracy of angle measurement the ratio horizontal component/vertical component at any position is independent of throughput.

(6) In all three series the calculated radial velocity component decreases from a maximum near the wall to zero at the air column.

(7) In all cases there exists an appreciable short circuit flow downwards near the outside wall of the vortex finder and between this flow and the downwards and inward flow near the cyclone wall there is a secondary upward and outward flow.

(8) The results show excellent agreement with an empirical relationship relating critical particle separation size with total volume throughput, particle specific gravity and cyclone inlet and overflow diameters derived by Dahlstrom in America.

* Summary of a paper presented at a meeting of the Institution of Chemical Engineers at the Geological Society, Burlington House, London, W.1, on February 12, 1952. This paper was first presented at a meeting of the Midlands Branch of the Institution.

German Chemical Plant

THE tenth Achema exhibition and convention is to be held at Frankfurt-am-Main from May 18-25. More than 500 firms are exhibiting their newest chemical plant, materials of construction and industrial instruments. At the same time the Société de Chimie Industrielle, France, will be holding its 25th Congrès International de Chimie Industrielle. Other foreign chemical engineering societies will also participate at a 'European Meeting of Chemical Engineering,' when several chemical engineering technical papers will be read and discussed.

Among the many exhibits, all of which are of interest to the chemical engineer, is a stainless-steel-clad cellulose digester. The manufacturers, **Carl Canzler,** also build digesters which do not need brick linings, up to 300 cu. m. capacity and 10 atm. pressure. What is claimed to be a new type of magnetic level indicator, for use in connection with the digester, will also be shown. New applications of their low-frequency induction heating to be demonstrated include an induction-heated, continuously-operating evaporator.

A new electrolytic unit for processing starch is among the equipment being shown by **A. Hering AG.,** who will also exhibit oil-cleaning and recovery plant and drying plant.

A new *Luwesta* extractor will be exhibited for the first time by the **Lurgi Gesellschaft für Wärmetechnik.** This unit is one-quarter the power of the extractor shown two years ago and is suitable not only for the antibiotics industry, as is the larger size, but also for the pharmaceutical industry as a whole and for research organisations for solvent extraction investigations.

A wide range of industrial instruments will be shown by **Eckardt AG.,** including a pneumatically-operated controller unit which can be used for regulating pressure, temperature, level or volume. They are also exhibiting an electromagnetic flue gas analyser for the determination of CO_2 and $CO + H_2$ contents in flue gases. This is an improved version of the conventional model and incorporates a magnetic device for obtaining a steady voltage. A chemical flue gas analyser will also be on view which can be fitted with a potentiometer-type transmitter for remote indication. A drum-type flowmeter for accurate measurement of the heat consumption in steam heating systems will be shown. It is built into the steam condensate feed-back and automatically meters the quantity of condensate returning to the system which is proportional to the steam consumption. The condensate volume is measured by the continuous filling and emptying of measures built in the measuring drums.

Durabilit rubber lining will be shown by **Franz Clouth AG.** It can be produced in a very hard form with an elastic underlayer. This company's vulcanisation plant is claimed to be the largest on the Continent. They also claim to have the largest presses on the Continent for producing conveyor belts up to a width of 100 in. Applications of their lining materials as covers for rollers for the textile and paper industry will be demonstrated.

Techniques of Chromatography

THE earliest uses of chromatography are unknown, but as an analytical technique it can be said to have developed from Tswett's separation of the chlorophylls. The original name is still used, in spite of the application of the method to colourless materials and to separations into portions of eluent rather than into adsorbed bands. The growing importance of the subject is reflected in the three symposia devoted solely to it in this country since 1940.

Chromatography was the subject of a lecture by Dr. Tudor S. G. Jones given at a meeting of the London & South-Eastern Counties Section of the Royal Institute of Chemistry, held at the South-West Essex Technical College, with Dr. C. W. Herd in the chair.

Dr. Jones said that a simple analogy of chromatographic action is provided by the distribution of a solute between two solvents, which can be developed further as distribution between a solvent and an adsorbent under the conditions of chromatography. Mathematical treatment of the process is disappointing and seldom leads to any prediction of practical application. The most comprehensive treatment is that of Martin and Synge, who applied the concepts of fractional distillation and found thereby that the efficiency of chromatographic separation may be some 200 times that of fractionation.

Although the techniques of chromatography can vary very widely, there are three main types of method: frontal analysis, where the solute is allowed to concentrate from solution at the solvent front; elution analysis, where a pure solvent is used to give further separation; and displacement development, where the addition of a solvent which is strongly adsorbed on the column has the effect of concentrating the bands.

Elution analysis frequently results in overlapping bands, but displacement development gives a much cleaner separation and is applicable to very much larger quantities of material. It has a much more promising future, and is applicable to ion-exchange separations, where behaviour can often be predicted if the affinity of the materials for the column is known. It has been applied also to the analysis of gaseous mixtures, where after passing through a charcoal column the gases may be characterised solely by their concentrations.

Many demonstrations of various techniques of chromatography, both column and paper, were carried out.

There was a large number of questions from an interested audience. In reply Dr. Jones described methods of packing columns, and stated that success depended largely on the nature and particle size of the materials. Suitable flow, under a head of eluent, was 100 to 200 ml. overnight. His experience showed that, while No. 4 filter paper was very good for paper chromatograms, No. 1 was better. There were advantages in using piles of filter paper—'chromatopiles.'

Thermodynamics of the steady state

In this monograph* Dr. K. G. Denbigh gives a brief but lucid account of one of the newest branches of thermodynamics—that of the steady state.

Classical thermodynamics is confined almost exclusively to equilibrium systems, and enables the consideration of an important but limited field of phenomena—chemical equilibria, phase changes, etc. Within the last 20 years, however, great strides have been made in opening up a whole new field of phenomena which are susceptible to thermodynamic treatment, phenomena in which, although equilibrium is never attained, the flow of energy which occurs is such as to leave the system unchanged over a period of time. Such a state is obtained, for example, when heat is supplied at constant rate to one end of a metal bar and removed at an equal rate at the other end, the temperature at each point in the bar approaching a stationary value. Such systems may be said to be in a condition of dynamic time invariance (steady state), as opposed to a condition of static time invariance (equilibrium).

Dr. Denbigh describes the development of the thermodynamic treatment of such systems from the early postulates of Kelvin in his consideration of the thermodynamic effect, through Onsager's work on the theory of microscopic reversibility, on to the very latest work, to which Dr. Denbigh himself has been a distinguished contributor. The subjects dealt with in the 97 pages of text include viscous flow, diffusion, thermo-osmosis, thermal diffusion, and flow of electric current. The treatment, although of necessity mathematical, is clear, and the discussion is thorough. The book is to be thoroughly recommended to all who desire an introduction to this new and fruitful field of theoretical research.

G. A. H. ELTON

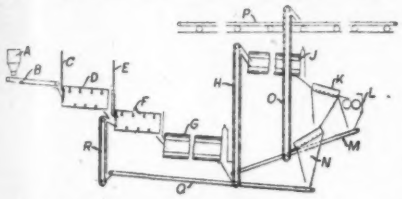
* *The Thermodynamics of the Steady State*, by K. G. Denbigh. Methuen, 1951. Pp. 103, including index. 6s. 6d. net.

Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Granulating superphosphates

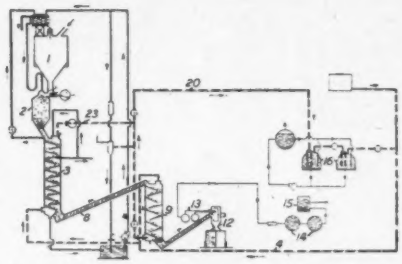
A process for the production of granular phosphatic fertilisers comprises treating cured superphosphate, or double or triple superphosphate, whilst being agitated and advanced, with a substantially non-acid aqueous liquid (*e.g.* water or an aqueous solution of a fertiliser salt) so that the material is just wet enough to break into small nodules, then introducing into it screening fines, and advancing the product while being tumbled until the screening fines have been largely taken into the nodules but still provide a dusty coating on the surface of the nodules, the amount of said screening fine being at least 50% by weight of the solid originally wetted.



In the drawing accompanying the provisional specification, fully cured non-granular superphosphate (and any non-superphosphate constituents desired) pass from smoothing hopper *A* to conveyor *B* and a rotary tube granulator *D* through which hot water passes from pipe *C*. Mixer *D* has internal flapping vanes and fixed spiral vanes. The amount of hot water is sufficient to transform the solid into small wet nodules which pass to a rotary conditioner *F* having internal flaps and fixed spiral vanes. Elevator *R* introduces fines from the final granulation. *E* is an additional water supply. The result: mixture and the fines leave *F* in the form of dusty covered nodules and are agitated in a rotary drier *G*, whereafter the elevator *H* lifts them to a rotary cooler *J*, from which they pass to a mechanically vibrated screen *K* (mesh, *e.g.* $\frac{1}{8}$ in. × $\frac{1}{2}$ in. side). Oversize material passes over the screen *K* to a toothed roller cracker mill *L*, and thence by chute M to join the material from drier *G* before being raised by elevator *H*. Material passing through screen *K* falls to a second mechanically vibrated screen *N*, which screens the fines on to conveyor belt *Q* for elevator *R*. The final granular product not passing through screen *N* is passed by an elevator *O* to a shuttle conveyor *P*.—612,856, *A. C. Van der B. Myburgh and Imperial Chemical Industries Ltd.*

Saccharifying cellulose

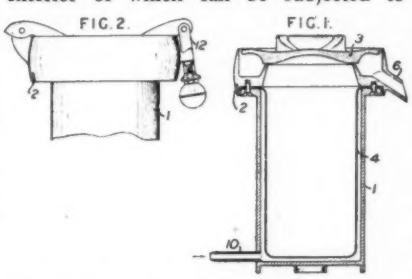
A continuous process for the saccharification of cellulosic material comprises impregnating the material by sprinkling it



with an excess of aqueous acid solution, maintaining the material in turbulent condition while subjecting it to an initial treatment by the acid in a gaseous state and then to a final treatment by the acid in a cold, gaseous, anhydrous state so as to dry the material and recover the acid used. In a preferred process comminuted wood is fed from silo 1 into mixer 2 where it is sprayed with aqueous hydrochloric acid. It then passes down tower 3, which may be of the type described in specification 606,465, in countercurrent to gaseous hydrochloric acid, which leaves the tower *via* pipes 23 and then passes through calcium chloride solution in tank 16 to be dehydrated before passing back to the apparatus *via* pipe 4. The treated wood passes up conveyor 8 and descends a second tower 9 through which passes anhydrous hydrochloric acid, which leaves by pipe 20 to the recovery plant. The dried hydrolised wood is washed in vessel 12 to remove all sugars which are concentrated in vessels 13, inverted in autoclaves 14 and neutralised to a syrup of 18° brix in vat 15.—614,433, *A. Hereng.*

Extracting fruit juices

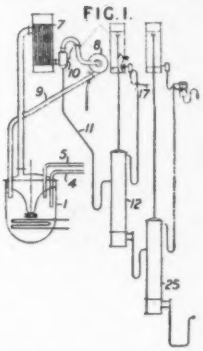
A press for separating liquids from solids, for use for example in the manufacture of fruit juices, comprises a container 1 with a compressible liquid-tight bag 4, the exterior of which can be subjected to



pressure from liquid supplied through a pipe 10, the bag being connected to the container by a flange 2 which has an imperfect joint, around its periphery, with a cover 3, so that on applying the pressure liquid and if desired fine solid particles can be forced past the joint, but larger particles are retained in the bag. The flange 2 has a channel provided with a discharge pipe 6 for the repressed liquid. The cover 3 is pivotally connected to the flange 2 and has a pivoted locking member 12 which can be adjusted to vary the pressure of the cover on the flange.—615,686, *C. Levysohn.*

Distilling aliphatic acids

In the manufacture of aliphatic acids by the catalytic oxidation of the corresponding aldehydes in the liquid phase, the aldehyde and a gas containing less oxygen than air are fed to a mixture containing the aldehyde, the acid and a catalyst, the gas being fed at such a rate that acid is carried away from the mixture substantially as fast as it is formed, and the alde-



hyde being fed at such a rate that the volume of the mixture remains substantially constant. The gas may consist of air and the residual gases of the process, and these may be fed separately into the reaction mixture. In the plant shown for the production of acetic acid, air and acetaldehyde are fed through pipes 4, 5 to a vessel 1 containing acetic acid, acetaldehyde and manganese acetate, and the gaseous and vaporous reaction products are cooled in a condenser 7. The gases separated in a separator 10 are returned in part by blower 8 and pipe 9 to the vessel 1, and the condensate from the separator is passed by pipe 11 to a column 12 in which acetaldehyde is separated and returned to the vessel 1 by pipe 17. The residue of aqueous acid is passed from column 12 to column 25, in which anhydrous acid is obtained by azeotropic distillation in the presence of an entrainer such as ethyl acetate. A similar plant is described for the production of propionic acid from a mixture containing propionaldehyde, propionic acid and manganese propionate, but in this case anhydrous propionic acid is separated directly from the condensed reaction products as a distillation residue in a two-stage distillation process.—603,175, *Usines de Melle.*

Plant and Equipment

H_2S removal from town gas

The well-known and long-established use of natural and 'artificial' bog ores containing active iron oxide for the removal of hydrogen sulphide, whilst accepted as satisfying the standard demanded by the Gas Referees, has two main disadvantages. Firstly, the volume of oxide required calls for large containers or boxes occupying valuable ground area and, secondly, the very unpleasant conditions for workmen when discharging and charging one box of the purifier set, coupled with the fact that these two operations take a long time. Two designs of purifying plant by R. & J. Dempster Ltd. provide alternative means of H_2S removal.

The 'Manchester process' of liquid purification employs an alkaline solution bearing a hydrated form of iron oxide for the removal of hydrogen sulphide to Gas Referees' Standard or 0.09 gr./100 cu. ft. of gas, the plant belonging to the absorption-oxidation group. The alkaline solution is maintained at a *p*H value of about 9, which buffers the hydrogen ion concentration at 0.01 the value of the dissociation constant of H_2S, thereby increasing the normal solubility of hydrogen sulphide in water one hundredfold. The fundamental chemical reactions are:

$$Na_2Co_3 + H_2S = NaHS + NaHCo_3$$

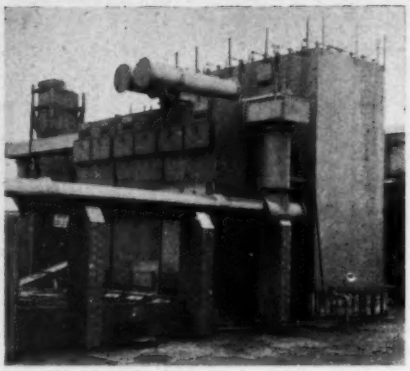
$$3NaHCo_3 + 3NaHS + Fe_2O_3 = 3NaOH + Fe_2S_3 + 3Na_2Co_3 + 3H_2O$$

$$2Fe_2S_3 + 3O_2 = 2Fe_2O_3 + 6S$$

Ammonia may be used instead of soda and the choice is mainly a question of economics.

R. & J. Dempster Ltd. were concerned with the first plant of this design to be installed in the U.K., which was at the Rochdale Road gas works of the Manchester Corporation. A subsequent installation on a coke oven works has proved its ability to remove H_2S continuously to the above figure. The plant mainly comprises a six-bay purifier, four-bay oxidiser unit, reaction tanks and defrother, with ancillaries such as main circulating pumps, charging and filter feed pumps and air compressors. The sulphur cake is handled, after pressing and drying, by elevator to storage hopper.

In the tray purifier type of plant, artificial or natural material containing active iron oxide is again the purifying medium, but the oxide is placed in two layers in trays arranged in multiple short tiers in a number of boxes to facilitate removal and charging. The foul gas enters beneath the boxes, being led to the central gasway of each tier, whence it passes through ports for passage up or down through the oxide layers in each tray. The gas connections may be arranged for reversal of flow if desired.



The first Manchester type liquor purification plant installed in Britain at the Rochdale Gas Works of the Manchester Corporation.

[Courtesy: North Eastern Gas Board

The pioneer installation of tray purifiers erected at the York Gas Works by R. & J. Dempster Ltd.

Speed of discharging and charging the boxes makes it possible to reduce the volume of oxide from that required by the orthodox designs, far less labour is required, working conditions are more tolerable and back pressure is very low.

A 4,000,000-cu.ft./day installation at the York gas works of the N.E. Gas Board is giving good service, and a projected 8,000,000-cu.ft./day installation will have mechanisation of the tray emptying and filling processes.

Both these plants are made by Dempsters under licence from the patentees.

New pH meter

Among the industrial instruments exhibited by W. G. Pye & Co. Ltd. at the Physical Society Exhibition, held last month in London, was an automatic self-balancing potentiometer and *p*H meter which has been designed for the measurement of *p*H values to an accuracy of 0.01 *p*H unit. In order to combine the accuracy of a manually-balanced potentiometer with the convenience of a direct-reading instrument, a self-balancing potentiometer is used. The potentiometer is geared to a four-figure counter which therefore directly indicates the *p*H value.

This new instrument is entirely mains operated and employs the same amplifier and mains stabiliser as the Pye direct-reading *p*H meter described in our July 1951 issue, p. 333. Zero stability and freedom from effects of mains voltage variations are therefore equally good. The potentiometer current is supplied by a high-stability gas tube and is constant to 0.1% over long periods; a built-in standard cell enables the current to be checked when required. Automatic temperature compensation is provided by shunting the potentiometer with a temperature-control element. Millivolt measurements can be made by operating a panel switch.

PVC reflectors for fluorescent lights

As an alternative to vitreous enamelled steel used in the construction of lighting fittings, Crompton Parkinson Ltd. have been developing a form of hard polyvinyl chloride reflector. A typical example of the application of this material is the new type AV. 1114 vapour-proof or dust-proof fluorescent fitting. These fittings were previously available with either a vitreous enamelled or *Perspex* reflector, but the new type has a hard PVC reflector. Although the original idea was to find a substitute for steel, investigations have proved that PVC has advantages of weight, durability and resistance to corrosion when used for certain types of work. Temperature limitations preclude the general use of PVC for all lighting fittings, but for the special Crompton vapour-proof and dust-proof designs it may actually be an improvement on steel.

The reflector is of light-weight white, opaque material, very flexible and difficult to break by straining or impact. It has a perfectly uniform colour and a reflection factor comparable to that of the highest quality vitreous enamels. It is said to be resistant to moisure, oils, alkalis and acids, and will therefore retain its colour indefinitely under normal conditions of usage.

In general it is recommended as a better alternative to the steel reflector type of fitting wherever this would normally be used, provided the ambient temperature does not exceed 100°F.

Other advantages of PVC reflectors are lightness in handling, reducing liability to damage during transit, installation and use.

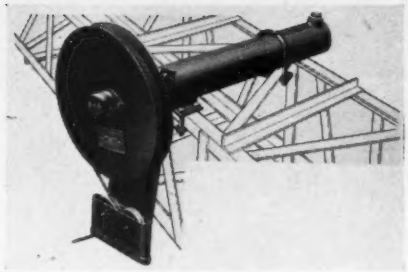
Automatic grabline for cranes

A device which can be attached to a crane jib to prevent the twisting and swinging of grabs or buckets is being marketed by the B. & A. Engineering Co. Ltd. It is particularly valuable where the grab is dumping into lorries or small hoppers. By its steadying action it ensures

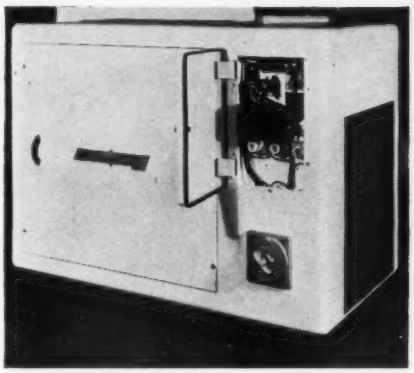
that the long side of the grab and long side of the receptacle are always in line, thus it assists sighting, speeds up the operation, gives more economic usage of labour and avoids waste of materials by spillage.

The ' B. & A.' grabline is a self-contained unit and it can be easily fixed to all types of cranes, without modification to crane or grab. It consists of a spring-loaded drum on which is wound a steel wire rope. The free end of this rope or cable is attached to the grab by a short chain or rope sling. Movement of the grab uncoils the cable from the drum against the action of a torsion spring, so that at all times there is a positive tension sufficient to steady the grab under all operating conditions whatever the angle of the jib. All working parts are enclosed in a sealed barrel, which also serves as an oil bath, obviating troubles from rust and grit. There are no sliding weights, brackets, pins or carriages to become disarranged or rusted by exposure.

The grabline is supplied complete with fair-leads and cable, ' U '-bolt and clamping plates. It can be fitted outside or inside the crane jib. Thimble and ' bull-dog ' type clamps are included to facilitate attachment of the free end of the cable to the sling on grab or bucket. Models for various size cranes are supplied.



Automatic grabline.



Air-conditioning cabinet showing interior of control system.

Air-conditioning cabinet

A self-contained air-conditioning cabinet has been designed by Thermocontrol Inst. Co. Ltd., primarily to provide accurate control of temperature and humidity in laboratories and standards rooms. However, it is equally suitable for installation in offices and boardrooms where a high standard of air conditioning may be desirable. It is particularly suitable for use where the quality and texture of materials, or the accuracy of instruments and laboratory tests are dependent on the maintenance of specific conditions within close limits. Rooms of up to 3,000 cu. ft. capacity can be accurately conditioned with this cabinet, and it is possible to maintain a constant temperature to within $\pm$ 5°F. and 0.75% relative humidity. For rooms of over 3,000 cu. ft., two or more cabinets can be satisfactorily installed. The cooling coils can be arranged to operate from existing refrigeration plants, or alternatively a small condensing unit can be provided operating on *Freon* or methyl chloride.

The cabinet is of bench height, which makes the top suitable as bench space, and easy access is provided for servicing and maintenance of all components, which include the following: replaceable glass fibre filter arranged in the air intake; centrifugal fan for air circulation with direct-coupled fractional horse-power motor and pedestal-type anti-vibration mountings; direct-expansion cooling coil; air heater with built-in high-limit thermostat; humidifying tank complete with ball float valve and immersion heater; room thermostat with relay to operate electric heater when temperature is low, or cooling coil when temperature is too high; humidistat arranged to operate cooling coil when humidity is high, or humidifier when humidity is too low; and built-in control panel, containing fan starter, interlocks, relays and fuses. In special circumstances, where close temperature control is required, step control of the heater battery can be arranged if desired.

Magnetic stirrer.

For further information on new plant and equipment, please complete the coupon on page 272.

The thermostat and humidistat are arranged either in the room or in the cabinet itself, depending on the sensitivity of control desired and the general arrangement of the cabinet in relation to the room to be conditioned. The approximate overall dimensions of the cabinet are 54 in. long $\times$ 28 in. deep $\times$ 34 in. high and prices range from £300 to £550 approximately.

Improved magnetic stirrer

This instrument has been devised to give the advantages of magnetic stirring at a low price, but with powerful magnetic attraction. The older types of magnetic stirrer tended to stop if anything deflected the rotating magnet, and would not then pick up again without the motor being slowed down and restarted. In the new model the magnet will pick up with ease.

The motor is a brushless constant-speed synchronous motor, of adequate power for stirring normal liquids, running at a constant speed of 200 r.p.m. It and its attached magnet are covered by a spun aluminium case, and the motor magnet itself is an *Alcomax* bar size 2 in. long $\times$ $\frac{1}{4}$ in. diameter. With this unit is supplied another *Alcomax* magnet of the same size sealed into a glass tube, and it is the use of these powerful opposed magnets which makes the stirrer so exceptionally self-starting.

Dimensions are 4 in. diameter $\times$ $2\frac{3}{4}$ in. high, and the price is £6 18s. Suppliers are Townson & Mercer Ltd.

Liquid fuel burner

A new type of heating device which burns a gaseous liquid fuel has been developed by Robert Reichhelm Co., U.S.A. It is claimed to save up to 20% on domestic and up to 50% on industrial heating costs. The device can be installed in existing standard hot-water and heating-oil burner tanks. It also burns heavier fuels more efficiently, leaving no carbon deposit. Air for complete combustion is supplied by an electric fan. Fuels used with the unit include kerosine and other fuel oils.

Automatic gas washer

An automatic gas washer which is a self-contained unit for producing intimate contact between gases and liquids, for use in gas washing, acid fume and dust removal, suppression of objectionable odours and for a wide range of chemical and manufacturing processes, is made by Kestner Evaporator & Engineering Co. Ltd. The plant is compact, it has no rubbing surfaces, and the parts are easily accessible for cleaning purposes. A wide range of construction materials can be used, including mild steel, stainless steel, copper, aluminium, lead, *Keebush*, etc. Sizes are available for outputs of 100 to 40,000 cu.ft./min. of gas, varying in power consumption from $\frac{1}{2}$ to 135 h.p.

World News

GREAT BRITAIN

Bennett's managing director elected B.C.P.M.A. chairman

Mr. H. V. Yorke, managing director of Bennett, Sons & Shears, Ltd., has been elected chairman of the British Chemical Plant Manufacturers' Association for 1952-53. Born in 1905, he was educated at Eton and Magdalen College, Oxford, and served a term of apprenticeship at Bennett's works in Birmingham. Mr. Yorke was a member of the U.K. Engineering Mission to Canada three years ago.

Mr. Yorke is married with one child.

Alloy steel supplies

Arrangements for economising in the use of nickel and molybdenum in alloy steel, and for increasing its production, have been worked out by the Ministry of Supply with the alloy steel makers and the main consumers.

The arrangements, which are already in operation to a substantial extent, become fully effective on June 2. In order that they should be applied generally the Minister of Supply (Mr. Duncan Sandys) has issued directions to steel makers.

Certain special types of alloy steels, such as tool steels and those designed to resist heat and corrosion, are not affected.

Apart from these, the general effect of the directions is to divide alloy steels containing nickel or molybdenum into three groups. These are:

(*a*) Those containing little nickel or molybdenum which may be supplied to any consumer of alloy steel up to the quantity for which he holds an authorisation under the Steel Distribution Scheme.

(*b*) Those, somewhat richer in these elements, which may only be supplied for particular purposes.

(*c*) Those, richer still, the supply of which is prohibited except as specifically approved.

A consumer who considers it essential to use alloy steel which cannot be supplied without special authorisation, may apply for this, in writing, to the Director of Alloy Steel Control, Ministry of Supply, Shell Mex House, Strand, London, W.C.2.

Notes for consumers are being issued through the authorising Government departments concerned.

Import of fertilisers

The Ministry of Materials announce that after June 30, 1952, the importation on public account of fertilisers and fertiliser raw materials (phosphate rock, potash salts, superphosphates and basic slag) will cease and the trade will be returned to the fertiliser manufacturers and merchants.

Import licences will be required thereafter.

Price changes

Copper.—The price of electrolytic copper was raised on April 1 from £227 to £231 per ton, delivered customers' works. Corresponding adjustments in the controlled prices of scrap and secondary metal have been made by the Ministry of Supply.

Sulphur and sulphuric acid.—The maximum prices for ground sulphur were reduced on April 1 by an average of £1 14s. per ton or approximately 7% on current prices, due mainly to a reduction in freight rates on sulphur. Maximum prices, however, will no longer include an amount to cover the cost of bags or other forms of package and the seller may now charge these separately. From the same date, sulphuric acid has been reduced in price by about 7%. The price reductions are 5s. 10d. per ton of weak sulphuric acid (77% H_2SO_4) and 8s. 6d. per ton of strong acid (more than 84.02% H_2SO_4).

Fertilisers.—Also, due to cheaper sulphur, fertilisers were reduced in price on April 1. The alterations vary with the type. Examples are: superphosphate (18% P_2O_5) from £14 19s. to £14 8s., ground phosphate (29% P_2O_5) from £12 11s. to £11 16s. per ton. Sulphate of ammonia and basic slag have not been reduced in price.

Autopack Ltd.

The Automatic Weighing and Packing Machine Co. have become a limited company with the new title, Autopack Ltd., the address remains the same, Caroline Street, Birmingham 3.

Food technology training

The Borough Polytechnic, London, celebrates the 60th anniversary of its foundation this year. It is expected that this event will be celebrated with the opening of the new building to house the departments of Food Technology and Chemistry in the late summer or early autumn. Now in an advanced stage of construction, this building has cost £250,000 and will make good the part destroyed by air raids.

Within two years of the establishment of the Polytechnic in 1892, instruction in bakery was provided and the Bakery Department, now renamed the Department of Food Technology to symbolise the widened scope of its work, has been the leading centre in England for the training of men and women for the cereal industries. There are two main courses in this section, a two-year full-time course leading to the National Bakery Diploma or a three-year full-time course leading to the Higher National Bakery Diploma for students wishing to obtain executive and other senior posts in industry. These courses can also be taken on a part-time basis although some full-time study is called for. The subjects in the Higher Diploma course include bread-making, flour confectionery, design and cake decoration, chemistry and physics, biology, organic and colloid chemistry, food analysis and experimental bakery work, applied science (biochemistry, nuitrition, microbiology, and hygiene), commerce and business management.

Courses in electrical and mechanical engineering and in chemistry are also held at Borough Polytechnic which at present has about 4,000 students, 800 of which are full-time, the rest part-time.

D.S.I.R. technical information

The Headquarters Technical Information Service of the Department of Scientific and Industrial Research has been merged with the Technical Information and Documents Unit. The new unit retains the name TIDU. Its address is Cunard Building, 15 Regent Street, London, S.W.1. (Telephone: Whitehall 9788.) The unit holds the German industrial documents which were brought back to this country after the war.

FRANCE

Sulphuric acid capacity increased

French production of sulphuric acid in 1952 is estimated at 1,600,000 metric tons (550,000 tons contact), depending on the availability of sulphur and pyrites.

Under the Monnet Plan, which contemplates an increase of 300,000 tons in contact facilities in the next few years, production capacity has been considerably renewed and extended since 1947. Construction of one large plant and four smaller ones for the manufacture of an additional 200,000 tons was completed in the summer of 1951, bringing the capacity for contact acid to approximately 550,000 tons annually. Two other plants with a combined capacity of 86,000 tons were to have been completed in 1952, but because of adverse market conditions in 1949 and 1950 construcution did not begin on schedule and the plants are not expected to be completed until late 1953 or early 1954. The country's total sulphuric acid capacity will then be approximately 1,900,000 tons, including about 640,000 tons contact.

GERMANY

Synthetic wax plant in production

The West German concern, Krupp-Kohlenchemie GmbH., of Wanne-Eickel, has started production of hard paraffin in its Fischer-Tropsch installations which have been modified for the purpose. The new hard paraffin synthesis process was developed by the firm in collaboration with Ruhrchemie-Oberhausen and Lurgi-Frankfurt/Main. This process is to be used in a similar plant recently built in France, which is starting production in the near future.

AUSTRIA

New coal-tar distillation plant

The Voest Company of Linz will shortly complete a new continuous pipe distillation plant with a daily capacity of 200 tons. In addition to light oils, the plant will produce carbolic, naphthalene and detergent oils, and also anthracene oils 1 and 2.

Voest are also preparing to turn out various intermediates for the chemical industry. Before the end of 1952, for instance, carbolic oil will be used for the production of crude phenol. Tests are being carried out to ascertain whether production of pure phenol will be practicable. Naphthalene will be used for distillation of pure naphthalene and phthalic anhydride. Phthalic acid is already being produced in a pilot plant at a rate of 1 ton per month, but the new plant is expected to have a monthly output of 80 tons. Another big unit is being built for the production of pure anthracene.

Hitherto output of coal-tar in Linz has been about 4,000 tons a month, with monthly coal consumption in the coking plant amounting to 135,000 tons. Output of benzole is around 1,300 to 1,400 tons monthly. Benzole is mainly used for mixing with benzene from the Austrian oilfields.

FINLAND

Drug output increased but big imports still needed

Finland's pharmaceutical industry increased its output considerably last year, turnover totalling 1,300 million marks compared with 900 million in 1950. Exports were negligible but imports of medicines and drugs were valued at 1,250 million marks including 370 million marks-worth of raw materials for conversion into finished medicinal products. In 1950, Finland's total imports of medicines and drugs were valued at 980 million marks.

Her most important suppliers of medicines in 1951 were Denmark, Britain and West Germany. Penicillin was among the main items imported, but plans are being laid to build penicillin plants and also, later, to start the manufacture of other antibiotics.

NETHERLANDS

Chemicals from seaweed

Alginac N. V., established in the Netherlands in April 1949, holds a concession to cut seaweed from the dikes of the Province of Zeeland and plans to manufacture chemical products from this raw material. Production is still in the initial stages, principally because of lack of capital. High costs make it difficult for the company to meet prices offered for these products by competitors in other countries, according to a report prepared by the Economic Technological Institute for Zeeland. Another difficulty is the limited amount of raw materials available, compared with seaweed resources in some other countries.

ISRAEL

Plastics plant planned

A $1,500,000 plastics plant is to be set up at Rehovoth, near Tel Aviv, by the U.S. Israel Toy and Plastics Corp. Two-thirds of the company's capital will be in dollars and the remaining third in Israeli currency.

Products to be made include rubber and leather substitutes, sheathing for electrical conduits and tiles. Raw materials will be imported and the plant will employ some 500 workers.

Mineral deposits exploited

After a year's survey Israel Mining Industries claim that it is now possible to mine phosphate rock, ceramic clays and glass sand found in the Negev area. Mining of phosphate rock has already started, but is slow because of the lack of equipment. It is expected that output will be sufficient for Israel's needs and also provide a surplus of 250,000 tons for export next year. The big deposits of ceramic clay in the Negev area are of average quality and, it is claimed, they can be used to replace most imported materials for the manufacture of ceramics. Proven reserves exceed 150,000 tons. The glass sands are said to be chemically pure and there are large reserves. There are deposits of copper and manganese ores north of Elath. The copper should be easy to extract, but it is not yet certain if there is sufficient to warrant operations. The reserves of manganese ores total at least 2,000,000 tons, which, it is hoped, will yield a product of a grade high enough for world markets. Deposits of mica and feldspar are being surveyed in the Elath region to discover if they are worth exploitation.

Oil prospecting project

Israeli officials have confirmed recent unofficial reports that representatives of Swiss and U.S. companies are ready to invest capital in test drilling for oil in Israel.

Unofficial reports said that an Israeli industrialist was negotiating with Swiss capitalists on the question of Swiss capital participation in oil prospecting in Israel. These reports claimed that a group of Swiss, U.S. and local industrialists which had already invested capital in Israeli cement and asbestos works was prepared to furnish considerable sums for oil drilling, and that a leading Swiss bank would also participate.

CYPRUS

New plasterboard factory

A plaster and plasterboard factory, which cost £500,000 to erect, has recently started production at Vassiliko, near Nicosia. Plaster of Paris, browning plaster, finishing plaster, wall boards and base boards are being manufactured. The company, known as the Gypsum and Plasterboard Co. Ltd. of Nicosia, is financed with Greek capital. It owns large gypsum quarries and has its own installation where ships can be loaded direct from the plant.

ITALY

More chemicals, fuels and metals

Production in most Italian industries has increased steadily since the war and pre-war output figures have been surpassed in many cases. In the chemical industry production of sulphuric acid has increased by 429,500 metric tons p.a. to 2,150,800 tons in 1951 (compared with 1,721,300 tons in 1938). Figures for caustic soda also showed an increase to 259,200 tons (165,000 tons). The output of non-metallic minerals for the most part increased, although that for pyrites fell to 814,400 tons (930,300 tons). The figure given for 1951 for raw fused sulphur was 191,200 tons, the average output for the previous three years. Pig iron output rose to 954,400 tons (862,000 tons), crude steel to 2,960,000 tons (2,322,900 tons) and hot rolled steel to 2,300,400 tons (1,658,300 tons).

In line with the increased industrial output, production of fuels has increased. The output of natural gas is now about 50 times greater than in 1938 and eight times greater than in 1948. It amounted to 888,800,000 cu. m. in 1951. The amount of motor spirit refined increased by 526,800 tons to 942,000 tons, more than double the 1938 figure. Fuel oil output also rose to 2,470,000 tons, nearly a six-fold increase over the same period.

This information is given by the Banca Nazionale del Lavoro in its 19th *Quarterly Review*.

YUGOSLAVIA

Asbestos plant starts up

The new asbestos processing plant at Bosansko Petrovo, near Tuzla, has started trial operation. The plant lies near rich asbestos ore deposits which will satisfy its requirements for the next 20 yr. The asbestos is of high quality, with fibres of from 10 to 25 mm. in length. The ore gives a 10% asbestos yield.

Output from the plant will be 1,200 tons of asbestos fibres this year. The normal annual capacity of the separator is 1,500 tons.

TURKEY

Two big fertiliser projects

The Turkish Government plans to set up a nitrogen plant in co-operation with West German firms who are to supply the equipment. German firms mentioned in connection with this project are the Badische Anilin und Sodafabrik and Friedrich Uhde A.G.

Total cost of the project is estimated at T£50,000,000 and the annual capacity is said to be 50,000 tons of ammonium sulphate, 15,000 tons of ammonium sulphate saltpetre and 3,000 tons of nitric acid.

Another Turkish fertiliser project is a 100,000 tons p.a. plant being built at Iskendenn. One-third of this company's capital is being supplied by American investors in the form of machinery and equipment. The rest is being subscribed by the Turkish banks and the chemical and machinery industries.

NORWAY

Fertiliser output to be raised

Norsk Hydro is to spend 500,000,000 kr. to increase production, according to a recent statement by the Norwegian Minister of Trade and Shipping, Mr. Evensen. The plant aims at a substantial increase in output of nitrogen and fertilisers, and production of the latter is to be raised from 40,000 to 140,000 tons p.a.

Norwegian agriculture, Mr. Evensen stated, also required 1,500 tons annually of *Myosil*, a liquid used for silage, and Norsk Hydro planned to build a factory with an annual capacity of 2,000 tons. The factory would cost 4,000,000 kr. and would take one year to build.

Iron ore mines rebuilt

The Syd-Varanger iron ore mines have now been rebuilt after wartime destruction at a cost of over £7,000,000. Production was resumed at the beginning of April at the rate of 500,000 tons of processed ore a year. From next year production will be 1,000,000 tons a year. Nearly all will be exported.

IRAQ

550-mile oil pipeline in use

The 556-mile, 30-in. pipeline from the Iraq Petroleum Co.'s oilfield at Kirkuk, North Iraq, has now reached its terminus at Banias, Syria, on the Mediterranean. Before it reached the coast 250,000 tons of crude oil were pumped into this £43,000,000 pipeline.

Although 115 miles of the 30-in. pipeline still have to be laid, it was possible to bring the system into operation by connecting the existing 12-in. and 16-in. pipes of the southern fork of the pipeline terminating at Haifa, which is at present inoperative. When in full operation shortly, the 30-in. pipeline is expected to convey an additional 14,000,000 tons/year of crude from Kirkuk to the Mediterranean. This is nearly double the 1951 production carried by the 12-in. and 16-in. pipelines to Tripoli, Lebanon.

FRENCH WEST AFRICA

Bulk handling of bitumen

A few weeks ago the first bulk bitumen reception facilities in West Africa came into service at Dakar, Senegal. For a long time France and French North Africa have benefited from a complete bulk bitumen distribution scheme. The extension of this method of distribution to French West Africa is a step forward in the Shell group's programme for the extension of bulk distribution, and follows the recent opening of large bulk depots in Denmark, Portugal and Ireland.

The bitumen will be carried by the Shell fleet of bitumen tankers. These ships will load regularly at the three refineries in France operated by Shell Berre: Pauillac, near Bordeaux; Petit-Couronne, near Rouen; and Berre, near Marseilles. At Dakar they will discharge through a specially lagged and steam-heated pipeline into a single 3,000-ton tank. This will operate, in association with a plant situated at the nearby Bel-Air depot, to blend the bitumen—which is a liquid only at comparatively high temperatures—with products such as kerosine so as to enable it to be used at lower temperatures. All these facilities will later be moved to a site on reclaimed land at present completely under water, where an oil storage farm, eventually to cover about 7½ acres, will be erected.

For the first time, the extensive road building and reconstruction programmes launched by the French West African Colonial Government will thus have the benefit of a bulk delivery of bitumen to the roads. It is estimated that one tanker load will suffice to cover between about 200 km. (say, 120 miles) of road as surface dressing for the local laterite gravels employed as the principal surfacing material on Senegal highways.

The delivery service of road vehicles will later be supplemented by rail tank wagons to ensure delivery in bulk over a wide area of Senegal and the French Soudan.

MEXICO

Sulphur output up

Sulphur production in Mexico this year should exceed the 1951 figure of 54,000 metric tons. The Pemex Co. is expected to increase slightly its 2,500-ton monthly output at a gas-washing plant at the Poza Rica oilfield, and a mine at Cerritos, San Luis Potosi, may also exceed its 1951 average of 2,000 tons monthly. Other sources of supply are expected to be opened in the Isthmus of Tehuantepec this year.

INDIA

Sulphur sources located

Probable sources of sulphur have been located in Ajmor near Delhi, Karwar in Bombay State, Mysore, Madras, and the Nilgiris in South India by the Geological Survey of India.

At Karwar in Bombay two promising exposures of pyrites have been found. The ore here was found to contain 20 to 25% sulphur and a little copper and nickel. Geophysical work in old pits near Chitaldrug in Mysore has indicated that sulphide ores found there are likely to extend over a length of 2,000 ft. At Wynad in the Nilgiris sulphur ores are associated with gold ores over an extensive area.

India's annual consumption of sulphur is about 63,000 tons, mainly imported from the U.S. and Italy. India's capacity for utilising sulphur is 80,000 tons a year.

New engine runs on lignite

A new type of engine, able to run on cheap fuels such as lignite, is being developed in the Department of Internal Combustion Engineering of the Indian Science Institute, Bangalore. It is designed to reduce consumption of imported oils and save foreign exchange by the use of cheap locally-produced fuels. (Large lignite deposits have recently been discovered in South India.)

The engine is reported to be simple and not to require the use of electrical fittings or costly injection systems. It can be made in types developing from 2 to 10 h.p., which are easily adapted to operate corn grinders, sugar cane crushers, rice mills and water pumps.

Solar cooker

A solar cooker, powered entirely by the sun's rays, has been installed in the Indian Prime Minister's house. The cooker,

which is said to be equivalent to a medium-sized electric cooker, consists of a 4-ft. curved, polished aluminium bowl suspended over the cooking pot, concentrating the sun's rays on a glass below the pot.

Several firms are interested in commercially producing the cooker, made by the National Physical Laboratory. They are expected to be mass-produced in a few months' time and the first ones are expected to sell at about 59 rupees.

PAKISTAN

Match industry expands

Four new match factories are likely to be started in East Pakistan in the near future, and some existing factories are adding, or have plans to install, new machinery. The new factories will add 1,650,000 gross boxes and the extensions to existing factories 1,000,000 gross boxes, to present capacity.

Total production of matches in East Pakistan factories in 1951 was only 150,000 gross boxes. Imports in 1950-51 amounted to 4,500,000 gross boxes compared with only 1,100,000 gross in 1949-50.

Salt manufacture in E. Pakistan

A site for an experimental Government sea-salt factory for the manufacture of salt by solar evaporation has been selected at Kutubdia Island in East Bengal. A sum of 50,000 rupees has been sanctioned for the experimental production of salt during the year 1951-52 and 70,000 rupees for the year 1952-53. Furthermore, in order to encourage the manufacture of salt in East Bengal, the Government has exempted from duty for a period of two years with effect from December 1, 1951, salt locally manufactured in East Bengal on a cottage industry basis.

NEW GUINEA

Dye from mangroves

A new industry, based on the exploitation of Papuan mangroves for the manufacture of mangrove cutch (a bark extract used in dyeing fishing nets) is being established in New Guinea by the South Borneo Mangrove Co. Hitherto confined to Borneo, the project is expected to earn the equivalent of A£300,000 annually in dollars and sterling.

JAPAN

U.S.-Japanese plastics plant

An agreement has been made for the formation of a company to manufacture plastic materials in Japan. The new company, known as the Asahi-Dow Ltd., will be an associated company of the American firm, Dow International and Asahi Chemical Co. Ltd., of Osaka and Tokyo. Each of the firms will hold 50% stock interest and will be equally represented on the board of directors.

EL SALVADOR

First cement factory

Construction is proceeding rapidly on El Salvador's first cement factory in the province of Sonsonate. It is expected to represent an investment of US $3,600,000 by the time it is completed and in operation. Within a few months of starting operations the factory should be turning out 900 barrels/day, representing an annual total of 1,080,000 bags/p.a.

According to the managing director of the new company, Cemento de El Salvador, the equipment being installed will be capable of handling 1,800 barrels daily if the company should in future decide to install a second kiln. The cement will be sold at a lower price than imported cement, and 200,000 bags annually will be available for export to Honduras a year after the start of the operations.

SOUTH AFRICA

Sheet-glass factory built

A new sheet-glass plant, built for Pilkington Bros. (S.A.) (Pty.) Ltd., has been opened at New Era, Springs. This firm is a subsidiary of the British firm of the same name. The plant has cost £800,000 to build and has sufficient capacity to meet all South Africa's sheet-glass requirements. All raw materials, except soda ash, will be obtained in the Union.

New wool-grease process

A new method of splitting wool grease into its constituent parts—acids and alcohols—has been patented by the South African Council for Scientific and Industrial Research. The process utilises lime and is cheaper and milder than the older, drastic chemical process, it is stated. The grease contains constituents needed for such products as cosmetics, vitamin D and hormones. Commercial firms will be granted licences to exploit the process.

Glue factory enlarged

A modern casein milling and processing plant has recently been installed at the Durban factory of the General Chemical Corp. Ltd., enabling improved grades of glues to be manufactured. In the past this company has also produced a large range of glues and adhesives which have found a ready sale locally but certain types still had to be imported. It is now anticipated that the company will be able to supply all S. African and Rhodesian adhesive needs in both the paste and powdered form, and also to export some glues.

Fatty acids from marine oils

A new process by which fish oils are split to yield fatty acids, including a stearic acid substitute, is being started by Marine Oil Refiners of Africa Ltd. It is estimated that 16,000 tons of marine oil could be extracted from the annual catch on the Cape west coast with the output of the above company at least half of this total.

Iron and steel output to be doubled

The production of South Africa's Iron and Steel Corporation will be almost doubled by present extensions to the industry. From an ingot production of 694,000 tons during the year ending June 30, 1951, it is hoped within a few months to increase the figure to 1,200,000 ingot tons annually.

The report points out that the price of European, British and American steel delivered to S. African consumers exceeds the S.A. Iron and Steel Corporation's prices by an average of £32 a ton. They are now some 73% over the 1939 level as compared with the official wholesale price increases for South African manufactured goods of 111%.

SOUTHERN RHODESIA

Gold mines turn to asbestos

Southern Rhodesia's asbestos output, already valued at over £5,000,000, is expected to rise by about 20% during the next eighteen months. By that time the value will then probably exceed that for gold, Southern Rhodesia's chief mineral. This increase is due in many cases to the rising costs incurred by existing gold mines, who are turning to asbestos mining on an increased scale. Another reason is that a wider range of applications and improved technology have led to increased uses and increased demands for grades of asbestos formerly useless.

One example of a gradual switch-over from gold to asbestos mining was cited by Mr. M. C. G. Meyer, consulting engineer to the General Mining & Finance Corpn., when speaking in Johannesburg recently. Mr. Meyer said that the normal gold-mining operations at the Antelope Mine had exposed chrysotile asbestos in various parts of the mine over a period of many years and there were surface exposures on other claims of the extensive property. Samples showed that the asbestos was of good quality, but it was too early to assess the economic importance of the deposits. Although it had not been decided to concentrate on asbestos production, the possibility was very interesting because of the advantages which would accrue from starting asbestos mining with an existing organisation and development at depth. Meanwhile mining for gold was continuing.

As further evidence of the interest in asbestos, the Anglo-Rand Mining & Finance Corpn. Ltd. has now entered the field in Southern Rhodesia, taking over technical control and development of 23 blocks of claims held by the General Asbestos Corpn. Ltd. in the Vukwe hills, near Shabani. Anglo-Rand are already known in Rhodesia as having initiated investigations, with Anglo-Colonial Territories Ltd., into the Lubimbi coalfields. Anglo-Colonial Territories are also interested in the agreement with General Asbestos.

Other big mining houses from the Union,

including African & European Investment Co. Ltd., either hold or have options on claims adjacent to those of General Asbestos in the Vukwes. Some of the Union's best financial and technical brains are converging on the Vukwes. New mines will be opened up, and established concerns will work dumps formerly considered unsuitable.

The increased asbestos output will be welcomed by the U.K., as it will provide a greater supply of asbestos for sterling, Canada being the chief world asbestos producer (see p. 122 of last month's issue).

Record mineral output

The output of the Southern Rhodesian mining industry is certain to have reached a record level in 1951. Up to the end of November the value of minerals (including gold) produced during 1951 amounted to £13,799,411—compared with the record figure of £13,606,704 for the whole of 1950. Outstanding among the minerals produced in the first 11 months of the year were: gold, £5,554,792; asbestos, £5,033,824; chrome ore, £1,395,911; coal, £1,214,559; tungsten concentrates, £235,975; beryllium ore, £85,521; mica, £66,332; tin concentrates, £51,763; limestone, £36,560; iron pyrites, £32,148; silver, £23,112; magnesite, £20,509; iron ore, £13,257; lithium ore, £11,170; and antimony ore, £10,883. There were less valuable outputs of copper, quartzite, vermiculite, fireclay, felspar, kaolin, arsenic, barytes, fluorspar and bismuth.

BRAZIL

Increased insecticide output

Three plants in Brazil produce benzene hexachloride, and output is at an annual rate of 6,100,000 lb. (12% gamma isomer basis), but the product is also imported. Two manufacturers have facilities for expanding output and expect to increase production in 1952.

New tin refinery

A tin refinery, in the final stages of completion at Volta Redonda, State of Rio de Janeiro, will have a yearly production of 2,500 tons of metal. With Brazilian consumption at 1,800 tons yearly, 700 tons will be available for export.

COLOMBIA

Soda plant completed

The recently completed Planta de Soda de Betania in Colombia has been under construction for three years by the Instituto de Fomento Industrial, a Government agency, at a cost of 25,000,000 pesos (2.51 Colombian pesos = US$1). It will produce 100 metric tons of soda daily for the manufacture of 50 tons of dense soda ash for the glass industry and 50 tons of light ash to be used in the manufacture of 30 tons of caustic soda and 12 tons of refined sodium bicarbonate. It is estimated that the new plant will save $4,000,000 annually in foreign exchange.

AUSTRALIA

Refinery expansion plans

Further plans for the expansion of Altona refinery, near Melbourne, operated by the Standard Vacuum Oil Co., involve an eleven-fold increase in capacity and an additional investment of $30,000,000. The new programme represents nearly a 50% increase in both plant size and investment over the original expansion plans, reported briefly in INTERNATIONAL CHEMICAL ENGINEERING, September 1951, p. 443.

The present Altona plant, owned and operated by an affiliate, Vacuum Oil Co. Pty. Ltd., has a crude-running capacity of 1,800 barrels/day. The construction plan, scheduled for completion in 1955, includes installation of crude distillation, catalytic cracking, reforming and treating facilities which will enable the refinery to process a total of 22,000 barrels/day. The expansion will add petrol and other fuels to the current production of lubricants, asphalt and diesel fuel.

When completed, Altona, in effect, will be a complete new refinery located on property adjoining the existing plant. The design will be sufficiently flexible to permit processing of a variety of crude oils, including New Guinea crude, on which the present small refinery operates. The new installation will be linked by pipelines to Vacuum's deepwater products terminal at Yarraville and to the Melbourne Harbour Trust's new crude-discharging facilities at Williamstown, both in the Melbourne area.

The expansion at Altona is the third major addition to the Standard-Vacuum organisation's refining capacity announced in the past months. They represent an investment of $82,000,000 and an increase of more than 54,000 barrels/day in the company's crude runs to refineries.

Ductile iron to be made

Ductile iron is to be made in Australia by three concerns under licence from the International Nickel Co. of America. According to a spokesman of the Division of Industrial Development, the move is a consequence of advice given by Dr. Hans Pohl, former technical director of the Skoda works, who recently visited Australia. Previously the lack of sufficiently refined pig iron had prevented manufacture of ductile iron.

Ductile iron can be used as a substitute for cast steel in some applications. It has many advantages over cast-iron.

Aluminium plant to be completed

The Federal Government has decided to spend a further A£4,000,000 on completing the aluminium plant at Bell Bay, Tasmania, according to the Minister of Supply. He said the Federal Government was anxious that the plant should go into production as soon as possible in view of the defence significance of aluminium ingot production to Australia, as well as the economic importance in avoiding heavy dollar expenditure. The Bell Bay aluminium plant was expected to make the first ingots early in 1954.

Originally the Federal and Tasmanian Governments were to contribute A£3,000,000. The additional A£4,000,000 would be sufficient to complete the plant to the stage where it would produce aluminium. The extra funds provided by the Federal Government should increase the original production estimate from 10,000 tons/year to 13,000 tons. The increased expenditure would make possible a 50% expansion of the size of the plant as originally planned.

Oil-from-coal prospects

Australia can produce oil from coal for less than the cost of imported petrol, according to a representative of Powell Duffryn Technical Services, U.K., who has been surveying prospects for the industry. He said Australia had unlimited resources of 'young' coal, ideal for the production of motor spirit.

His Queensland survey showed that a A£30,000,000 plant at Blair Athol could produce 300,000 tons of motor spirit a year, enough for between 70 and 80% of the State's requirements. The fuel could be produced for 10d./gal., 25 to 33% under the imported price of refined spirit. The heavy cost of transport could be overcome by a 650-mile pipeline to Brisbane, which would add only ¾d./gal. to production costs. The octane value from Queensland deposits would be 80, compared with the 72 of imported spirit. He added that Victorian brown coal was also suitable for oil production.

Stressing the economic significance to Australia of the oil-from-coal plants, he said that the largest of their by-products would be fertiliser, one of Australia's big import items.

CANADA

Pyrites sulphur project

A concern backed by European and Canadian capital, Sulphur Converting Corporation plans to build a $5,000,000 sulphur plant at Roberval, Quebec. Canadian Government officials said the project was well advanced, that land had been purchased and that plans had been made for mining in the Chibougamau region for pyrites, from which sulphur will be produced by a special process. The company, headed by J. A. Leclerc of Montreal, hopes to start construction of the plant in May and to reach the production stage by 1953.

New chemical engineering company

A new corporation, Chemical Construction (Inter-American) Ltd., has been formed with main offices in Toronto. A subsidiary of American Cyanamid Co., U.S.A., it will design and build chemical plants in all Western Hemisphere countries except the U.S.A.

UNITED STATES

Nitrogen target nearly 3,000,000 tons p.a.

The Defense Production Administration has approved Federal tax benefits to assist a $114,534,646 expansion of nitrogen-producing facilities by ten companies. The plants will make an additional 425,000 tons of nitrogen a year upon completion. The defence goal is 2,930,000 tons a year by 1955.

Sulphur in 1953

In the annual report of the Freeport Sulphur Co. the chairman estimates that by the end of 1953 annual output of brimstone in the U.S. will be increased by 1,200,000 tons. He also reckons on 500,000 tons of sulphur in other forms and 1,300,000 tons more from other countries. Freeport claim to be spending $20,000,000 on new sulphur production facilities.

Cold rubber in half the time

A new process, which will make possible a 30% increase in the production of cold synthetic rubber, has been developed, according to Mr. J. R. Hoover, president of the B.F. Goodrich Chemical Co. The process uses a 'tetra-sodium salt of ethylene diamine tetra-acetate' which, when added to the water used in making cold rubber, forms complex compounds with iron, calcium and magnesium in the water. The new chemical brings reaction time down from 13 hr. to about 9 hr., making possible production of more cold rubber in each polymeriser during a given period. Chemical treatment of the water also cuts the amount of catalysts required for rubber production.

Chemists at the Goodrich Co.'s Port Neches plant, where the process is being used, have succeeded in cutting in half the 18-hr. reaction time required for rubber production in 1949, thus doubling reactor capacity for cold rubber without addition of any new equipment. Through the reduction in the amount of auxiliary chemicals required, the overall cost of the rubber is also slightly lower. The cold GR-S produced under the new process is claimed to be more uniform in quality and can be turned out under less exacting technical control.

New polythene plant

A 50,000,000-lb. p.a. polythene plant is being built at Texas City. It will form an extension to the plant of the Carbide and Carbon Chemical Co. The production process will involve the direct polymerisation of ethylene at high pressure. The resulting solidified materials will be in granular form. The unit is expected to be in production by early 1953, when the total annual production of polythene in the U.S. will reach nearly 150,000,000 lb. It is anticipated that if the rearmament programme continues at its present rate the 1953 requirements for urgent uses will still be in excess of the country's polythene output.

New styrene copolymer

The U.S. Rubber Co. has developed a new thermoplastic moulding and extrusion compound which, it claims, will retain its toughness and high impact strength at temperatures as low as 60°F. The new material, known as *Kralastic J*, is a styrene copolymer. Initial uses are expected to be confined to military applications on equipment for arctic use and for aircraft which reach low temperatures at high altitudes.

New shale-oil extraction process

A new process claimed to extract more of the oil from oil shale than previous methods has been patented in Washington. Other methods normally 'fluidise' the oil shale, changing it into a fine powder to give it some of the characteristics of a liquid. When the fluidised shale is distilled the heat necessary for distillation is supplied by burning portions of the combustibles in the distillation zone. Some of the oil is lost through burning in this method. The new method avoids this loss of oil, the inventors claim. Heat is supplied by adding another fuel, such as coal, which may be used either in a separate heater or added to the powdered shale. If the added coal fragments are of a larger size than the shale fragments they will burn, while the shale and some of its oil will not. The patent has been assigned to the Standard Oil Development Co.

Rival to 'Cellophane'

A polyester film, *Mylar*, similar in appearance to *Cellophane*, has recently been developed by the Du Pont Co. It is said to have high strength, good heat resistance and insulating qualities, and to be flexible at low temperatures. It has high dimensional stability under heat and humidity changes and has good resistance to chemicals. It is being produced experimentally on semi-works equipment in limited quantities. Although the film is being tested in a number of industrial fields, it is expected to be several years before it is generally available commercially and even longer before its use will be fully developed. It is expected to find major uses where other commercial films are not suitable. The most promising field appears to be electrical insulation. It is also likely to be used in the industrial tape field to widen the use of film-based tapes, combined in laminations with other materials, for packaging and for collapsible tubes.

Chemically, *Mylar* is a condensation polymer obtained from ethylene glycol and terephthalic acid. It belongs to the same family as *Terylene* developed by Imperial Chemical Industries Ltd. in England and has been developed after a study of the British research by Du Pont. *Dacron* polyester fibre was first obtained and later *Mylar*. Research expenditure of more than $3,000,000 was required to develop the polymer for film use and to develop the process and equipment.

New mica process

The chemical division of the General Electric Co. has announced a new method of producing mica insulators which, it is believed, may make the country independent of foreign mica supplies. The bulk of the mica flake now used in the electrical industry is imported from India.

In the new process, domestic mica is pulverised and the impurities removed. The microscopic flakes are then subjected to treatment which forms them into a continuous sheet. This sheet can be produced in thicknesses ranging from 0.002 to 0.006 in.

The new product, called *GE Micamat*, is claimed to have better dielectric properties than natural mica products. This is attributed to the greater uniformity of thickness and to the absence of holes. It can be impregnated with resins and bonded to glass, paper and cloth. Production on a commercial scale may necessitate the reopening of U.S. mica mines.

Nickel-coated aluminium

A nickel-coating process which is claimed to give aluminium the hardness and resistance to corrosion of nickel has been developed by the Hamilton Standard Division of the United Aircraft Corp. and the Bart Laboratories Inc. The essential element in the process is a synthetic rubber compound used to establish a bond, formerly unattainable, between the aluminium and the nickel plate. The plating process takes about 24 hr. The finished pieces have a semi-bright surface, but can be polished chemically or mechanically to a high lustre.

New pulp mill

A $55,000,000 newsprint plant and pulp mill, to be built in the U.S. by the Bowater Paper Corp., is expected to be in operation within two years. The plant would produce 130,000 tons of newsprint and 50,000 tons of kraft sulphate pulp annually, according to the chairman of Bowaters. He also stated that the new plant and mill would be only the beginning of something greater. Adding that technical problems regarding the use of the yellow pine had been overcome by advances in chemistry, he suggested that the acceleration of the growth of yellow pine was among the factors influencing his corporation to make their 1947 investigation into pulp production in the southern states.

Sawdust-fuelled gas turbine

Combustion efficiencies of 92.5 to 99% have been obtained with a sawdust-fed gas turbine developed at the Oregon Forest Products Laboratory, Corvallis, Oregon. Heat release rates up to 900,000 B.Th.U./sq.ft.-hr. based on grate area and 200,000 B.Th.U./cu.ft.-hr. based on furnace volume were realised in the laboratory furnace. Based on grate area, it was claimed this heat release volume was about three times as high as that in most sawmill in-

stallations producing steam from log fuel. Based on furnace volume, the heat release is about 15 times that usually obtained in most boiler installations using wood fuel.

An experimental unit was constructed and has been in operation since November 1950. It is an aircraft supercharger set up as an open-cycle gas turbine, using a waste wood-fired combustion system comprising an underfeed stoker supplied with undergrate air, overfire air jets and dilution air admitted above the furnace.

New phenol plants

It is announced that the directors of the U.S. Monsanto Chemical Co. have approved plans for the construction of a phenol plant at Avon, California. The plant is scheduled for completion in 1954 and will use a process recently developed by the company. Construction will begin in about five months.

Plans to build an $8,000,000 plant for the production of phenol, para-cresol and acetone by a new process have been announced by the Hercules Powder Co. The new process was said to be equivalent to that developed in Britain by the Distillers Co. Ltd.

A 13,000,000 lb./p.a. phenol plant operating by the same process is also to be built at Montreal in Canada, see INTERNATIONAL CHEMICAL ENGINEERING, 1952, January, p. 45.

Bethlehem Steel expansion

An additional $40-45,000,000 expansion programme has been announced for the Sparrows Point mills of the Bethlehem Steel Co. A $75,000,000 expansion programme was begun last year. The two programmes will bring ingot production at the mills to 6,000,000 tons p.a. by the end of 1953.

Mr. Grace, chairman of the company, said the programme would include a blast furnace, a battery of 64 coke ovens, open-hearth department refinements and improvements, and complementary mill extensions.

Titanium for jet engines

Titanium has been shaped successfully for jet engines, according to the Cyril Bath Machinery Co. A spokesman said rings or circles of complex cross-sections were completed accurately on the company's new 'rotary draw former.' Titanium could withstand temperatures up to 3,510°F., was lighter than steel and could bear a stretch or tensile pull up to 140,000 p.s.i. It had been described as the 'replacement metal' for all steel parts in plane construction once the cost of refining it was reduced.

At present the metal sold for $25/lb. and had been used only in experimental stages.

The Bath Machinery Co. conducted its experiments in conjunction with the planning department of the gas turbine aircraft division of the General Electric Co.

Blow extrusion of vinyl plastic

A process which makes possible the manufacture of a tough, transparent vinyl plastic film of 0.001 in. thickness, or less, has been developed by the Naugatuck Chemical Division, United States Rubber Co.

The process is expected to open extensive markets for vinyl film in industrial and consumer packaging. The process utilises a method known as 'blow extrusion,' where the film which is based on *Marvinol* VR 10 resin is extruded through a circular die at temperatures between 375 and 425°F. The film can be produced in widths exceeding 100 in. It is possible to obtain 50 sq. yd. of film from 1 lb. of raw material.

ARGENTINA

Coking plant tenders

The Ministry of Industry and Commerce is calling for tenders for the construction and putting into operation of a plant producing metallurgical coke. Bids will be opened on May 16.

MEETINGS

Institution of Chemical Engineers

GRADUATES' AND STUDENTS' SECTION

May 16. Symposium, 'Chemical Plant Construction' (9 a.m., 'Plant Fabrication'; 2 p.m., 'Plant Erection'), Caxton Hall, Caxton Street, London, S.W.1.

May 17. Annual general meeting, 10.45 a.m., Department of Chemical Technology, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7. The chemical engineering laboratories will be on view from 12 a.m. to 1 p.m. after the meeting.

May 21. Symposium, 'Research Work of the University of Birmingham Chemical Engineering Department,' 6.30 p.m., The University, Birmingham.

Society of Chemical Industry

May 14. Corrosion Group. Annual general meeting followed by papers on 'The Prevention of Corrosion in Packaging,' 6.15 p.m., Chemical Society, Burlington House, Piccadilly, London, W.1.

Chemical Society

May 16. 'Application of Electric Dipole Moment Measurements to Chemical Problems,' by Dr. L. E. Sutton, 5 p.m., Physics Dept., University College, Southampton.

Institute of Petroleum

May 14. 'Distribution of the World's Oil Reserves,' by G. M. Lees, 5.30 p.m., Manson House, 26 Portland Place, London, W.1.

Fertiliser Society

May 8. 'History of Fertiliser Manufacture in Britain,' by W. G. T. Packard, 2.30 p.m., Manson House, 26 Portland Place, London, W.1.

Physical Society

May 8. 'Heat Transfer at Low Temperatures,' 5.30 p.m., Lecture Theatre, Science Museum, South Kensington, London, S.W.7.

INTERNATIONAL CONFERENCES

May 18-25. Achema X. Conference and exhibition of chemical plant, Frankfurt-am-Main, Germany. Joint meeting with the 25th Congrès International de Chimie Industrielle, organised by the Société de Chimie Industrielle, Paris, France.

May 25-30. General meeting, German Association of Gas and Water Technicians and Association of German Gas and Water Works, Essen, Germany.

June 3. Annual meeting, International Whaling Commission, London.

June 4-10. 'Progress in the Field of Raw Materials used in the Mechanical Engineering Industry,' Fourth International Mechanical Engineering Congress, Stockholm, Sweden.

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